Twenty-Eighth Annual
Report

OF THE

State Board of Agriculture

AND THE

State Agricultural College

INCLUDING THE

NINETEENTH ANNUAL REPORT

OF THE

AGRICULTURAL EXPERIMENT STATION

FORT COLLINS, COLORADO

1906

DENVER, COLORADO
THE SMITH-BROOKS PRINTING CO., STATE PRINTERS
1907

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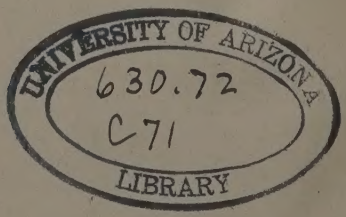
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LETTER OF TRANSMITTAL.

To His Excellency,
THE GOVERNOR:

Sir—Herewith I transmit my annual report as Secretary of the State Board of Agriculture. It is respectfully commended to your attention and to the thoughtful consideration of the General Assembly.

A. M. HAWLEY,
Secretary of the State Board of Agriculture.

The State Agricultural College,
Fort Collins, Colorado, November 30, 1906.

SECRETARY'S REPORT.

REPORT OF THE RECEIPTS AND DISBURSEMENTS OF THE COLLEGE FUNDS FROM DECEMBER 1, 1905, TO NOVEMBER 30, 1906, INCLUSIVE.

RECEIPTS.

Tax Fund.		
Balance, December 1, 1905	$ 3,961.55	
Receipts	69,755.00	
		$ 73,716.55
Land Income Fund.		
Balance, December 1, 1905	$ 1,357.22	
Receipts	18,354.31	
		19,711.53
Annie Jones Library Fund.		
Balance, December 1, 1905		1,175.31
Special Fund.		
Balance, December 1, 1905	$ 1,432.61	
Receipts	12,590.03	
		14,022.64
Appropriation Agricultural Instruction Fund.		
Balance, December 1, 1905		3,986.77
Appropriation Farmers' Institute Fund.		
Balance, December 1, 1905		7,102.66
United States Mechanic Arts (Morrill) Fund.		
Balance, December 1, 1905	$ 8,416.79	
Receipts	25,000.00	
		$33,416.79
		$153,132.25

DISBURSEMENTS.

Agricultural Department—		
Agronomy Division	$ 780.72	
Animal Husbandry Division	5,414.25	
Farm Division	5,842.15	
Farm Mechanics Division	236.58	
General Agricultural Division	4,732.20	
Farmers' Institute Division	5,003.19	
		$22,009.09
Advertising		2,039.28
Bulletins and Reports		1,114.30
Association A. A. C. and Experiment Stations		15.00
Chemical Department		759.75
Commercial Department		16.65

DISBURSEMENTS—Continued.

Constitutional History and Irrigation Law Department	53.85	
Current Expense	804.10	
Civil and Irrigation Engineering Department	2,019.17	
Domestic Science Department	551.06	
Rhetoric and Composition Department	9.15	
Electrical Supplies	162.90	
Freight and Express	1,557.01	
Fuel and Lights	4,785.86	
Firemen and Janitors	3,282.26	
General Repairs	2,043.04	
Girls' Dormitory	785.41	
Horticultural Department	3,465.00	
History and Literature	27.50	
Insurance	993.75	
Library	2,695.19	
Mechanical Department	2,368.39	
Mathematical Department	8.60	
Military Department	74.22	
Music Department	118.84	
Modern Languages Department	13.45	
President's Office	1,442.67	
Physical Training Department	17.30	
Permanent Improvements	14,060.31	
Salary	61,807.02	
Secretary's Office	985.82	
State Board of Agriculture	1,291.40	
Student Labor	3,655.80	
Text-Book Department	3,305.01	
Veterinary Science Department	352.30	
Zoology and Entomology Department	222.66	
Transfers to other funds	3,790.28	
		$142,703.39
Tax fund.		
Overdraft, November 30, 1906	$ 1,994.55	
Land Income Fund.		
Balance, November 30, 1906	$ 358.05	
Special Fund.		
Balance, November 30, 1906	3,210.80	
United States Mechanic Arts (Morrill) Fund.		
Balance, November 30, 1906	8,854.56	
		$10,428.86
		$153,132.25

REPORT OF RECEIPTS AND DISBURSEMENTS OF FUNDS PAID INTO THE SECRETARY'S OFFICE IN CONNECTION WITH SPECIAL FUND.

RECEIPTS.

Domestic Science Department	$ 10.25	
Mechanical Department	36.33	
Chemical Department	57.50	
Freight, etc., Refunded	195.60	
Text-Book Department	2,884.00	
Entrance Fee	380.00	
Library	66.95	
Music Fee	207.75	
Horticultural Department	11.25	
Girls' Dormitory	345.61	
Registration Fee	36.00	
Physics Department	9.85	
Civil and Irrigation Engineering Department	270.00	
Appropriation	3,328.41	
Agricultural Department—		
General Agricultural Division	$ 725.06	
Agronomy Division	28.57	
Animal Husbandry Division	4,805.64	
Farm Division	32.40	
	$5,591.77	
		$13,431.27

DISBURSEMENTS.

Remitted to the State Treasurer for credit of Special Fund as per receipts on file	$13,431.27

REPORT OF THE RECEIPTS AND DISBURSEMENTS OF THE EXPERIMENT STATION FUNDS FROM DECEMBER 1, 1905, TO NOVEMBER 30, 1906, INCLUSIVE.

RECEIPTS

Hatch Fund.		
Balance, December 1, 1905	$ 1,554.40	
Receipts	15,000.00	
		$16,554.40
Adams Fund.		
Receipts		$ 6,750.00
Special Fund.		
Balance, December 1, 1905	$ 686.05	
Receipts	5,756.23	
		$ 6,442.28
Appropriation Animal Industry Fund.		
Balance, December 1, 1905		$ 9,360.76
Appropriation Plant Industry Fund.		
Balance, December 1, 1905		$ 2,058.29
Appropriation Root Crops Fund.		
Balance, December 1, 1905		$ 1,000.00
		$42,165.73

DISBURSEMENTS

Agricultural Section	$ 56.27	
Arkansas Valley Sub-station	54.12	
Animal Investigation Section	2,024.11	
Agronomy Section	2,483.55	
Bulletins and Reports	5,457.19	
Buildings	5,236.68	
Chemical Section	1,345.47	
Director and General	1,716.58	
Entomological Section	1,053.05	
Horticultural Section	1,570.48	
Insurance	33.00	
Library	1,912.63	
Meteorological and Irrigation Section	2,347.39	
Salary	11,136.07	
Veterinary Section	951.83	
Western Slope Fruit Investigation	2,428.11	
Transfer to other funds	1,124.57	
		$40,931.10
Hatch Fund.		
Overdraft, November 30, 1906	$ 286.47	
Adams Fund.		
Balance, November 30, 1906	455.26	
Special Fund.		
Balance, November 30, 1906	1,065.84	
Balance, with Treasurer, November 30, 1906		$ 1,234.63
		$42,165.73

REPORT OF THE RECEIPTS AND DISBURSEMENTS OF FUNDS PAID INTO THE OFFICE OF THE SECRETARY IN CONNECTION WITH THE EXPERIMENT STATION SPECIAL FUND.

RECEIPTS

1905-1906.

Horticultural Section	$ 10.74	
San Luis Valley Sub-station	280.09	
Director and General	599.19	
Arkansas Valley Field Agent	8.00	
Agronomy Section	265.34	
Western Slope Fruit Investigation	1,424.87	
		$ 2,588.23

DISBURSEMENTS

Remitted to Station Treasurer for credit of Special Fund as per receipts on file	$ 2,588.23

SUMMARY

NAMES OF FUNDS	1905			1906
College	Balances	Receipts	Disbursements	Balances
Tax Fund	$ 3,961.55	$ 69,755.00	$ 75,711.10	*$ 1,994.55
Land Income Fund	1,357.22	18,354.31	19,353.48	358.05
Library	1,175.31	.....	1,175.31	.....
Special	1,432.61	12,590.03	10,811.84	3,210.80
Mechanic Arts (Morrill) Fund	8,416.79	25,000.00	24,562.23	8,854.56
Appropriation				
Agricultural Instruction Fund	3,986.77	.....	3,986.77	.....
Farmers' Institute Fund	7,102.66	.....	7,102.66	.....
Animal Industry Fund	9,360.76	.....	9,360.76	.....
Plant Industry Fund	2,058.29	.....	2,058.29	.....
Root Crops Fund	1,000.00	.....	1,000.00	.....
Experiment Station				
Hatch Fund	1,554.40	15,000.00	16,840.87	*286.47
Adams Fund	.....	6,750.00	6,294.74	455.26
Special Fund	686.05	5,756.23	5,376.44	1,065.84
	$42,092.41	$153,205.57	$183,634.49	$13,944.51
				2,281.02
				$11,663.49

*Overdraft.

REPORT OF THE PRESIDENT.

The State Board of Agriculture:

Gentlemen—I submit the following as the Twenty-seventh Annual Report to The State Board of Agriculture. It is accompanied by reports from the heads of the various departments, for which I ask the most careful hearing.

The year has been one of remarkable vigor in the prosecution of the work of the Institution, both in the school and throughout the State. The College and Experiment Station, realizing their obligation to the active farmers of the State, many of whom have recently come to Colorado, have done as much extension work as time and means would permit. Farmers' institutes have been held in many parts of the State. Important bulletins have been printed and widely circulated. Two horticultural experts have been established on the Western Slope in connection with the fruit growers of Mesa county. Much good has issued from this; chiefly, the organization of the fruit growers of the Western Slope, for the protection of their industry and for giving assistance to the College. Many valuable experiments are in action, and orchardists are patiently awaiting final results. I recommend that in the appropriation bill you ask for $20,000 for Horticultural experiment work throughout the State.

The College experts have visited every portion of the State where perplexing difficulties have arisen and have given much valuable aid. The Farmers' Course is in session at the present time with an enrollment of seventy-five. A short course in forestry will be held here February 18th as ordered by this Board. A school in horticulture for the Western Slope will be held in Delta, beginning January 14th and lasting one week, which gives promise of being the most successful effort the College has recently attempted . A remarkably fine exhibit from the College and Experiment Station was made this year at the State fair and several of the smaller fairs. The cost was considerable, but I am sure it was a paying investment. It will be much less expense hereafter.

Correspondence with practical farmers has greatly increased, and much practical work is being carried on, as the accompanying reports will show. I am sure the Board realizes the importance of this extension work. It carries the College directly to the farmers, who need its help. It makes them positive and lasting friends, and makes it far easier to reach the farmers' children and interest them in the work of the College. Like all honorable effort to do one's duty, it brings its own rewards. I think the State wil gladly grant the Institution at least $8,000 a year for the further prosecution of this extension work.

The work of the school has grown more stable and logical. The Board is a unit in its determination to give to the four great departments, i. e., Agriculture, Civil and Mechanical Engineering and Domestic Science, equable support. Upon these four corner stones we are rearing a substantial structure.

A few changes in the teaching force have been made. Those who have recently come to us are strong men and are giving marked satisfaction. Any school might be proud to have its entire faculty composed of such men as Bainer, Coen, Cottrell, Gay and Paull. They have been selected with great care and are more than fulfilling our expectations. I question if a stronger Faculty may be found in any Agricultural College in America than the one this Board has the honor to direct.

As the Board is well aware, the work of this Institution for some years past has been fundamental. We have strengthened the courses of study by striking off the first preparatory year, by adding a year at the top of each course, and by such other changes in the remainder of the curriculum as will best make excellent working experts and good citizens. We have been searching, in fact, for the best possible Agricultural College Curriculum, keeping always in mind the needs of our own State. The Land Grant Colleges have been compelled to slowly find their destiny in the educational world. We think the problem has at last been solved. Their function is three-fold: experimentation, instruction and dissemination. These are met by the Experiment Station, the College, and the institute or extension workers. More and more the members of each of these three groups must work each within his own group. To be sure the ideal condition is that the experimenter shall teach enough and mix enough with the active farmers to keep him fresh and give proper direction to his experiments.

In spite of the lopping-off process, by which four courses have been eliminated from the Institution, we have held our own in enrollment, with a decided gain this present year.

The short course scheme, for which we all have worked so long, has come to stay. Nearly one hundred young men and women are with us at the present time for the three months' work. Some twenty who were here last winter have returned for more advanced work. Others returned last fall for the long courses. These short course students are bright, hard-working and appreciative. I trust their number will increase so rapidly that by another year we may find it advisable to abandon the First Sub-Freshman year of our present system. Then our student body will have a higher age average, come better prepared, having finished the tenth grade elsewhere, and the school will be able to assume more college-like methods. Every alumnus with whom I have talked supports this proposition.

By reason of our constant growth, our fixed charges have become so great that new buildings, or the enlargement of the

present buildings, have been out of the question. Until more room is provided we should not hope for a great increase in enrollment, for it will be impossible to provide comfortable accommodations. With the addition of one hundred short course students now here we are uncomfortably crowded. Many departments are severely handicapped for lack of space. It is clear, therefore, that large appropriations must be asked of the Sixteenth General Assembly if we are to do more than retain our present development. I advise the calling together of those in charge of the departments of Agriculture, Civil Engineering and Domestic Science, at once, for a conference on new buildings. An Agricultural Hall, a Civil Engineering Building and a combined Domestic Science and Girls' Dormitory building must be had within the next two years by some process. It is probable that if two of these could be secured by special appropriations the third may be provided for by private generosity; but procured they must be. The time is favorable, the need is imperative, and the wisdom of the Board must do the rest.

As already stated, further appropriations are needed for extension and experimental work. These requirements will be presented to you in accompanying reports.

I should now like to ask you to consider some important legislation. The State Forestry Association has issued a Memorial to the State in general, and the coming Assembly in particular, in which they ask for the establishment of a Chair of Forestry in this Institution, with sufficient appropriation from the State for its support. This means, if it is to succeed, that the Board must give the measure its heartiest support. We should give the matter a definite expression at this time. No State in the Union is making or will make such demands for instruction in the growth and preservation of forests. Irrigation being the basis of our agriculture, it might almost be said that the mountain forests are the basis of irrigation. If a Chair of Forestry is to receive state or government aid in Colorado, it must be patent to everyone that it should have connection with a State Institution. The State Agricultural College already has much of the equipment needed, a number of the present members of its Faculty have been giving elementary instruction leading to more advanced work. The establishment of such a Chair in this Institution would at once claim the confidence of the entire State.

Professor Gillette has proposed a bill which makes the Entomologist of the College the State Horticultural Inspector, with a company of deputies. The former is to be paid by the State, the latter by the counties wherein the work is done. Owing to the fact that Colorado is fast becoming the first fruit State in America, and that already great injury has been done the industry by reason of ignorance and negligence, such legislation as is here indicated is greatly needed. The leading fruit men of the

State will give it their unqualified support. I recommend that the measure have the full endorsement of this Board.

I desire to know if it be your wisdom that the time is opportune for the introduction of a bill requiring the teaching of elementary agriculture in the rural schools of the State after, say, July 1, 1908. The State Normal School avows itself as willing to co-operate with us both in respect to the bill and in giving at the State Normal a course which shall prepare teachers in this branch by the time the law becomes operative. There are many reasons for enacting such a law. There are a few in opposition; mainly, however, as to the timeliness of such a measure in Colorado.

In all probability a measure will be introduced before the coming Assembly, asking for an appropriation for experimental work in dry farming on the plains. The Department of Agriculture, at Washington, stands ready to grant a sum equal to that which shall be appropriated by the Legislature for dry farming experimentation, provided the work is carried on by this Institution in conjunction with the United States Government. It will be necessary for the Board either to prepare the bill, or look after its interests if the bill is proposed by others.

Some general legislation must be had by which the State revenue shall be increased. This must be done either by amendment to the Constitution, adding one or more mills to the four mills state tax, as at present, or by a legislative enactment to the present revenue law and the present methods of assessment. A conference of all institutions is to be held at an early date to seek relief in this direction. Representation in this conference must be provided for at this meeting of the Board. It is of supreme importance. The State is now possessed of sufficient wealth adequately to care for all of its institutions. The reason for the present lack of funds lies either in the method of assessment or in the fact that the State has not provided itself with a sufficient mill rate.

Another member of the Board will report later relative to a proposed bill concerning the relationship of this Institution to the State Land Board and the college lands now under its control.

This, I believe, covers the legislative question, apart from appropriations. And these can only be determined upon by you after consultation with the Departments of Agriculture, Domestic Science and Civil Engineering.

I wish to recommend that your permission be granted the Committee on Faculty and Courses of Study to prepare for the next annual catalogue a new course of study for women.

I feel that a more general course, in addition to the present Domestic Science Course, will attract many more women students than we seem to be able to reach at the present time. Domestic Science should by all means hold a dominant place in the new course, if one is to be formulated.

I desire also to recommend that so far as possible a special crew be provided for institute work, if sufficient appropriations are made by the coming Legislature, in order that the members of the Faculty may not be overtaxed in time or energy, as at present, often to the injury of their regular class-room work in the College.

I desire also to recommend that at the earliest possible moment buildings and money will permit the course in Veterinary Science be restored. The recent meat inspection bill passed by Congress has greatly increased the demand for competent veterinarians, who shall instruct stockmen in a proper care of animals and in the prevention of diseases.

There are some other minor recommendations which I shall submit later, since they are merely formal and do not require Special Committee action.

Respectfully,

B. O. AYLESWORTH,

President.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF AGRICULTURE.

To the Honorable State Board of Agriculture:

Gentlemen—I have the honor to present herewith my third annual report covering the work of the Agricultural Department of the College and Experiment Station during the past year.

Several changes have been made in the staff of this Department during the year. Prof. J. A. McLean, who occupied the Chair of Animal Husbandry, resigned in June to accept a more lucrative position in the Iowa Agricultural College. Prof. H. M. Cottrell, formerly professor of agriculture in Kansas, was secured to fill this position.

Pursuant to instructions received at a former meeting of the Board, a Committee composed of the President of the College and the writer, secured Prof. H. M. Bainer, Professor of Farm Mechanics in the Iowa Agricultural College, to take the Chair recently established in Farm Mechanics in this Institution. Professor Bainer came to us the first of July this year and has already accomplished a great deal in the way of organizing this Department. He has added a vast amount of farm machinery to our already very good collection, and his work with students in operating this machinery and in carrying on some investigations with motive power has been very successful.

The appropriation made by the last Legislature for the carrying on of experimental work in the Divisions of Agronomy and Animal Husbandry has aided us greatly in carrying the research work done in this Department along these lines.

Since the last annual meeting, the new experiment horse barn, with a large number of corrals and paddocks, has been completed and is now occupied by the horses and colts in the co-operative horse breeding experiment.

The steer feeding and the hog feeding experiments proposed in my last annual report have been undertaken and are well under way, giving promise of some results that will be of great value to the live stock interests of this state.

Through the kindness of Mr. F. J. Hagenbarth, ex-President of the National Live Stock Association, we have been provided with a carload of choice lambs for the carrying on of feeding experiments the present winter. The lambs are now on feed at the College barns and an experiment has been outlined in which we will test the comparative value of finely cut or ground alfalfa meal with alfalfa hay as a feed ration for fattening lambs.

The work in hog feeding as outlined is very elaborate, and is, in brief, to make a study of the grains and other feeds that are available for hog feeding purposes in this state in an effort to determine their comparative feeding value for the production of high class meats, more particularly the production of choice bacon. I believe that Colorado possesses greater possibilities along this line than are to be found in any other state in the Union, and I feel that it is the duty of the College and Experiment Station to point the way in this field of endeavor to the farmers and stock men of the State. From information received from one of the large packers in Denver it is apparent that over $4,000,000 worth of hogs and pork products are annually shipped into this state to supply the market here. If, by carrying on some investigations that will give some definite information on this subject, we will be able to direct the farmers and stock men along the channels of pork production it will be the means of greatly increasing this industry, which is now a comparatively neglected one.

A very complete hog feeding yards and stables have been constructed and are now ready for occupancy. These pens and yards have been divided into ten equal parts and will accommodate 100 head of hogs. With these yards the station is fairly well equipped for investigation work on a small scale.

The proposed lines of investigation in hog raising is submitted by Professor Cottrell in his report, a copy of which is herewith presented, which will give a definite idea of the work that we hope to accomplish in the near future if funds can be appropriated for the carrying on of this work.

The horse breeding experiment is going forward in splendid form. We have, as a result of the year's work, fourteen very promising colts from the eighteen mares bred. Recently the Department of Agriculture has increased the stud of breeding mares by two very good individuals from Kentucky. The five yearling colts are doing well and we hope will develop into something that will bring some revenue for the future conducting of this experiment.

LIVE STOCK.

The stock on the farm has increased in numbers and in quality during the past year, with no great expenditure of funds. The inventory shows that we have on the farm at present fourteen head of Shorthorn cattle, valued at $2,105; five head of Hereford cattle, valued at $625; seven head of Holsteins, valued at $875; seven head of Ayrshire cattle, valued at $650; two Red Polled animals, valued at $250; ten Aberdeen Angus cattle, valued at $1,360; one Highland cow, valued at $60; five steers and two spayed heifers, valued at $560. The total value of cattle owned by the College is $6,485.

In sheep we have seven head of Oxfords, valued at $200; nine head of Southdowns, valued at $160; of Rambouillet, four head, valued at $75, and thirteen head of Shropshires, valued at $360, making a total of $795 worth of sheep owned by the College.

In the hog department, we have thirty-three head of Poland Chinas, valued at $592; nine head of Berkshires, valued at $475; nineteen head of Tamworths, valued at $565, and one Yorkshire sow, making the total valuation of our swine amount to $1,709.

In the horse department in the past year we have added two of the finest Percheron mares in America. This purchase has been made possible largely through the liberality of one of the largest importing firms in America. One of these mares produced a very fine colt this summer, and is, I believe, again in foal. We also have added a pair of work horses, giving us a total of twelve head of horses. These horses are valued at $3,515, making the total valuation of live stock owned by the College, at a very conservative estimate, amount to $13,141.

Owing to the increase in number of our live stock made necessary by the horse-breeding experiment and the steer-feeding experiment the additional pasture of 560 acres purchased early in the spring enabled us to have good pasture all summer for our stock and to have them in good condition for the coming winter. With the inevitable increase in breeds that we must maintain to successfully carry out our plans, I would respectfully recommend that an additional tract of land consisting of another 240 acres lying immediately north of the tract purchased from Benny Harris, that is now for sale, should be secured without delay. The 560 acres purchased during the past summer has not an adequate water supply. The half section mentioned as lying north of it contains a large lake which would give an abundant supply of good water for our stock at all times without any added expense. As this land is constantly increasing in value it would seem to be the part of wisdom to secure it without delay. The land purchased in the spring has been fenced on three sides with good woven wire fencing. It still requires some additional fencing to make it safe.

The addition of the Experiment Farm that we have had possession of for the first time this year has made possible a line of work in grain, grass and root investigation under the direct charge of Professor Olin and his assistant, Mr. Knorr, that is bound to be of the greatest value to the agricultural interests of this State. The research work along the lines of increasing the disease resistant powers of plants is in itself promising great returns for the money expended. In addition to the alfalfa work started, a study has been made of the most important varieties of oats, samples of which have been secured from all over the United States and from the countries of the Old World as well. Some of these varieties have proven exceedingly prom-

ising, one of them yielding at the rate of 127 bushels per acre of clean oats. There was also grown in the experimental plots the common varieties of barley and the common varieties of wheat, including those of strong drouth resistant powers which were grown without irrigation. The research work started this year in a study of sugar beets, looking toward the increase of the sugar content and the production of Colorado grown seed is very promising of the results desired.

The work in variety tests on the Experiment farm has been the most expensive ever conducted at the College, the following being the complete record:

Varieties of oats, 28, two increase plots; varieties of wheat, 23, two increase plots; 17 varieties of barley, three of corn, 24 of sugar beets, a like number being for cultural experiments, nine of rutabagas, five of mangels, six of carrots, nine of peas, and some 20 plots of miscellaneous plants.

Already the land available for experiment work is crowded with variety test investigations. We must soon make some arrangements for additional land where the most promising of these varieties can be tested in the field on a larger scale, and when they have proven their superiority over varieties in common use among the farmers, we can produce them in sufficient quantities for distribution throughout the State. I sincerely trust that the option on 80 acres of land lying immediately south of the Experiment Farm, and known as the Mrs. Taylor place, may be secured this winter, that this very important work may be carried on. I would respectfully urge upon the Board the necessity of having the importance of this matter presented to the Legislature at its coming session with a sufficient appropriation for securing this land.

The cooperative work undertaken with various farmers throughout the state has been productive of valuable results. This has been treated of very fully by Professor Olin in his report, which has been submitted to the Director of the Experiment Station. I trust that this line of work may be carried on in the future and extended in its scope, as its results are of great value to the farming interests of our State.

The Farm Mechanics Division of the Agricultural Department presents some of the most important problems for solution, and I would urgently request that this Division be made a section of the Experiment Station at once. A vast amount of research work is already crowding us in this direction. With the great progress that has been made in motor engines and the demands for them at the present in farm operations makes the duty almost imperative. If the farmers of the State of Colorado are to continue to lead along agricultural lines, they must do so through the medium of improved machinery, and it is the duty of the College and Experiment Station to fully investigate the farm machinery offered on our markets, that we may recommend the kind most likely to be of benefit to our farmers.

Another very important phase of the Farm Mechanics work just now pressing in Colorado and one which has attracted a great deal of attention on the part of our business men, is that of road building. This properly belongs to the Farm Mechanics Division of our College, and I hope that it can be made a strong feature of the work offered to students. I do not believe there is anything at the present time that we could do that would tend to popularize our Institution more quickly than such a course in road building as we could put in.

The Farmers' Institute Division of the Agricultural Department of the College has met with a very gratifying success. This work has been fully reported upon by the Superintendent of Institutes, a copy of which is presented herewith.

The College farm proper was never in as good condition as it is at the present time. The fences have been improved and extended and the ditching and drainage contemplated has been partially completed. There is still much to do in the way of leveling various sections of the farm that will render it much more valuable, for it can then be successfully irrigated. If this could be done it would enable us to supply a larger portion of the feed required for the live stock as this Division grows. More fences and corrals will be required the coming year and we will also require more equipment in the way of horses to enable us to properly care for the land that we have and for that which we hope to acquire. I trust that these may be forthcoming when the time arrives.

INSTRUCTION.

It is very gratifying to report that never before in the history of the College has so much interest been shown by the students in the Agricultural Department. We have registered this year in the various classes of the Agricultural Department of the College 110 students, not including those who will attend the two short courses that are now being offered.

Owing to the additions to our teaching force, the work of instruction is now on a broader scope and substantial gains have been made in attendance. Sixty students of the first and second Sub Freshman years who have signified their intention of taking the Agricultural Course have been organized into a special class and are being given some instruction in live stock work. This is supplying in part a long felt demand on the part of these students for some practical work in the lower classes of our College, and I am sure it will be of great influence in encouraging them to continue in their College work.

With our present equipment of buildings, we will be able to work along for a time without additional class rooms by using the offices of the various instructors as class rooms for some of the more advanced students where the classes are small. If the attendance increases very much, as it has every prospect of doing,

there will be a serious demand for increased class room accommodations in the very near future.

A number of our best students desire to continue their work here after graduation, particularly with their study of live stock, and as they can aid us materially in the investigation work we have under way, I trust that you may see fit to provide from time to time a sufficient number of scholarships to enable these young men to carry their work to completion and to enable us to have the benefit of their services.

NEEDS OF THE DEPARTMENT.

As before stated, we should have additional land for the successful carrying out of our College and Experiment Station work. The one-half section of pasture land we should secure will not cost above $12 per acre, or $4,000. The 80 acres adjoining the Experiment Farm will cost $250 per acre, or $20,000 in all. This additional land would give us sufficient area to carry forward our work in both Agronomy and Animal Husbandry Sections for many years to come. Since options have been obtained on this land it would seem almost imperative that a special effort be made to secure it at this time.

We are greatly in need of a suitable building for storing experimental grains. The upper floor of the Farm Mechanics building makes a very satisfactory laboratory for carrying on seed selection work and in storing the smaller samples for seeding the experimental plots which were started this last year, but it will be necessary to take care of the seed resulting from these experiments if any lasting good is to be derived from what we have already done. A suitable building could be erected for about $3,000. This would give us facilities for putting in apparatus to test the milling properties of the various wheats that are being experimented with. The wheat farmers of this state have suffered a great loss through a combination on the part of the millers of the state the past season to keep down the price of durum wheat, claiming that it made inferior flour. It seems very important that milling tests of this and other wheats should be carried on and this could be done in a suitable grain room, reliably and very cheaply on a small scale, as it is now being done in Minnesota, Utah and Washington Experiment Stations. It is desirable to test all wheats grown and developed here for their milling qualities and we should be able to do this in our own laboratory.

Owing to the large amount of machinery that has been secured at no cost to the College other than the payment of freight, it is necessary for us to make some further provision for the housing of this machinery. We have had donated to this Institution $12,500 worth of machinery and if the manufacturers are showing sufficient interest to let us have the use of their machines for demonstrations and tests it is certainly up to us to see that it is

properly taken care of. Such a building as we have had in mind could be constructed for not to exceed $2,500, and this would enable us to remove the machinery now stored in the class room recently built for demonstrating the working of Farm machinery, for the use of students, in the regular as well as the short courses.

In our experimental work with live stock the appropriation received from the last Legislature should be duplicated and an additional amount secured if possible. The stock men of the state are evincing a great deal of interest and are supporting us in every way. I believe the time is opportune to ask for liberal appriations for every division of our work. We have been receiving annually, for the past two years, $5,000 from the special appropriation, and we should have the same amount for the next two years for live stock experiments.

In the Agronomy Department, we have been getting from the State appropriation annually, for the past two years, $2,500, and this should be doubled, that the work may be taken care of as it should be, that we will not be subjected to criticism for neglecting to care for our experiment work through lack of funds. This amount would be sufficient to carry on the work in the improvement of alfalfa and other forage plants, as well as the root crops and the cereals that we have already under way.

In the Farm Mechanics Section, the sum of $1,500 in addition to the amount required for store room will enable us to carry forward this new branch of our work in a very satisfactory manner.

For Farmers' Institutes we have been receiving $4,000 annually for the past two years, and to make the work more effective an additional $1,000 should be asked for, making $5,000 available annually for this work. This will enable us to issue a hand book prepared by our institute lecturers in the form of an annual report to be distributed among the farmers of the State.

There has been an urgent demand from all parts of the State that a Poultry Department be established at this College. This, it seems, is a very important division of College and Experiment Station work and should receive some attention from us, and I believe there is an excellent opportunity to secure, from the Legislature funds to establish such a department. The expense would not be great and the returns from it when once well established should be greater than the expense in maintaining it. I think we could put in a respectable plant and maintain it for the next two years for not to exceed $4,000. This would enable us to erect suitable buildings, to equip the course and to employ a man to take charge of the work, which will be a necessary expense.

The total amount required by the Agricultural Department for the next biennial period, including purchase of land, erection of buildings, purchase of equipment, Farmers' Institute work, and the carrying on of proposed investigations in the Agronomy, Animal Husbandry, Farm Mechanics and Poultry Divisions, is in

round numbers $62,000, of which $24,000 is for the purchase of land, $5,500 for the erection of much needed buildings, $4,000 for Poultry Department, $10,000 for Farmers' Institute work, $10,000 for Animal Husbandry work, including the horse breeding experiment, $6,000 for Agronomy and $3,000 for Farm Mechanics, including road building. Our experience has taught us that we can not depend upon any great amount from the Hatch and Adams funds except in the matter of salaries without encroaching on other lines of investigations equally as important, else this amount asked for might be reduced appreciably in the Agronomy and Animal Husbandry Divisions.

In conclusion, I take this opportunity to express my deep appreciation of the courtesy and kindness of the Board during the past year in granting me a four months' leave of absence in order that I might be enabled to study the practices of the leading stock breeders of Europe. I wish also to express my appreciation of the liberality of the Board in providing ways and means for the carrying on of the most important demands of work in the Agricultural Department.

Respectfully submitted,

W. L. CARLYLE,
Dean of Agriculture.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE AGRONOMY DIVISION OF THE AGRICULTURAL DEPARTMENT.

Prof. W. L. Carlyle, Dean of Agriculture, Colorado Agricultural College.

Dear Sir—I take pleasure in giving you a detailed report of the work of my Department from December 1, 1905, to December 1, 1906.

1. *Class Work.* This past year I have had classes in Agronomy work, as follows:

Winter term, 1905-6, a class of twenty-five in Farm Mechanics; the work of this class consisted of class lectures once a week and shop work in iron and steel ten hours per week. The State Poultry Association offered prizes for the boys of the Farm Mechanics class who presented the best and most practical Colony Poultry House. Albert Cross, L. C. Aicher and R. C. Littler went to the State Association held in Denver in January with models of poultry houses which they had made in the shop. The boys explained the plan of their houses to the hundreds of visitors who inspected them, and one dealer in fancy poultry has adopted Mr. Littler's design for his colony houses. This work attracted favorable attention, and the State Poultry Association stands ready to assist us in a substantial manner in making this work interesting and of practical value to the boys. Prizes were awarded on the models shown: Littler, first; Aicher, second; Cross, third. I have recommended to Prof. Bainer (who now has this work) that it be broadened and emphasized, and that the Poultry Association be invited to give liberal prizes each year for models of colony houses from original designs; that other prizes for practical models, useful on the farm, be secured from interested individuals or associations. The shop work in iron and steel consisted of fourteen practical exercises in forging. Mr. William Elzinga, Instructor in Moulding, Forging and Foundry Work in the Mechanical Department, was the instructor in the shop work, and while he had very large classes in the Mechanical Course, by some changes he found room and time for the Farm Mechanics shop work and reported a deep interest in this work on the part of the boys. As soon as we can, we should have shop arrangements especially adapted for Farm Mechanics instruction, so we will not need to so seriously inconvenience the work and workers in the regular Mechanical Engineering shop work.

This term I also had the Junior students in the Agricultural Course in Study of Soils three times a week. While there had been no arrangements for definite laboratory periods in the

catalogue for this work, the class found time to take laboratory work. Mr. Knorr directed the laboratory work in Soils. We had practically no apparatus for this work, no place to store said apparatus and no room where this essential work could be done. Our work in this study was greatly strengthened by assignment of a definite amount of laboratory work in Soils in the new year's catalogue, and we have arranged to use the dairy room when dairy classes are not in session. Mr. Knorr will direct the laboratory work in Soils and I will give the class lectures. This term I also had the Senior Agricultural students in Farm Management. This work is becoming an essential feature of the Agronomy work in all colleges where instruction in Agriculture is given. I fully believe that each Senior who comes to this class should have had at least twelve weeks' experience or apprentice work on a western stock ranch and twelve weeks' apprentice on a western farm where general farming is practiced. I would recommend that we make arrangements to give all Agricultural students in the four year course this apprentice work during the Sophomore and Junior summer vacation periods. That we further urge at least one year's field practice work in a responsible position on some suitable ranch or farm, after graduation, under the direction of the professor of that department of Agricultural work in this College where the student desires permanent employment. There are many calls for farm managers which we cannot fill because we have few students who are fitted for the responsibilities which this work entails. Each farm manager of to-day needs thorough instruction in Animal Husbandry, Agronomy and Farm Engineering, with *plenty* of ranch and farm *apprentice* work unless he has been brought up on a farm and is very familiar with all classes of farm operations. Two correspondents are even now urging me to send them each a farm manager for large ranches in the West and Southwest, and I cannot do it, because our work has not been established long enough to give the boys the training this work requires. Let us plan to do some thoroughly practical work along this line of farm management, for there will be pressing calls for workmen along this line of agricultural work and our schools will be valued and rated by the preparedness of our graduates and their practical efficiency.

Spring Term, 1906. The Agricultural Sophomores come to me in the spring term for class instruction and laboratory work in Field Crops. I know of no text book now written which emphasizes the fundamental principles and gives a classification and discussion of crops adapted to our conditions. I am therefore writing the text which shall combine the lectures and an outline of the laboratory work, which I feel will prove interesting and beneficial to our Agricultural students, in a manner which I desire to place in the students' hands. There is a dearth of text books in all our modern agricultural work. Mr. Knorr

was of great assistance to me in the laboratory work during this Spring term. I had special students this term doing research work in Agronomy.

Special Courses. Beginning the first week in December, the first Short Course work in Agriculture for the farmer boys and girls was inaugurated. Fifty students, varying in age from 18 to 35 years, applied for this work. It proved a success from the start. The course, covering three months—December, January and February—was crowded full of instruction in those lines of study and research work which can be carried at once into the practical work of the home and farm life. I had classes in Field Crops and Farm Mechanics. Two Western Slope girls led the class in term standing in Field Crops; one, Miss Emma Larson, gained a grade of 98 and is deserving of special mention. The second term of this Short Course work will be taken up this present month of December, when I will give instruction in Soil Fertility and Farm Management.

Farmers' Ten Day Course. This work was given the third and fourth weeks in January. You will remember that you granted me two days for grain and forage work and one day for Farm Mechanics work. We were able to secure Prof. W. J. Spillman, Agriculturist for the U. S. Department of Agriculture, Prof. C. A. Zavitz of the Ontario Agricultural College, to lecture on Agronomy subjects and Mr. S. M. Woy, General Manager of the International Harvester Company at Denver, to lecture on Farm Mechanics subjects.

One entire day was given to demonstration work by the students in Farm Mechanics work, Long Course. The forenoon session was given to general discussion and demonstration work of models presented of haystackers, racks, feed racks, gates and poultry houses, with miscellaneous exercise work in iron and steel. The afternoon session the students gave a threshing demonstration, all the work from running the engine to sacking the threshed grain being done by the Farm Mechanics students of the school under the direction of Mr. Smith, Assistant to General Manager J. F. Albright, of the J. I. Case Threshing Machine Company, and Mr. Wm. O'Brien, Superintendent of the College farm. A demonstration with gasoline engines, with a lecture on same, was given by Mr. S. M. Woy, of the International Harvester Company, Denver, and this was followed by a manure spreader demonstration in the field. Each spreader was filled with well rotted barn-yard manure, and this load was scattered in a chosen field on the College farm. The following machines were sent to the College and used in this field demonstration work:

1. New American Spreader, from American Harrow Co.
2. Success Spreader, from John Deere Co.
3. 20th Century Spreader, from Parlin & Orendorff Co.
4. Great Western Spreader, from Smith Mfg. Co.
5. International Harvester Co. Spreader.

After this field work with the spreaders, the farmers were invited to a cleared space adjacent to the Farm Mechanics building, where several thousand dollars' worth of modern machinery, which I had prevailed upon various farm implement companies to loan the College, was placed on display. Representatives of the various manufacturing companies were present and explained to interested questioners the use and efficiency of the various machines.

Farm Mechanics Day was so crowded full of helpful instruction and interest, that I trust you can see your way clear to make it a permanent feature of each year's course for the farmers. Here the manufacturers can get the benefit of the farmer's ideas and criticisms, and the farmer gains a better conception and a keener appreciation of the modern machinery the twentieth century is bringing to his aid.

Chair of Farm Mechanics. One year after I had taken up the Agronomy work with you, when I felt sufficient interest and work had been developed to justify it, I recommended that this division of the Agronomy work be made into a new Chair, coordinately with Animal Husbandry and Agronomy. This suggestion was approved by you and, upon your recommendation, the Board authorized the establishment of this chair, and called Prof. H. M. Bainer, of the Iowa State College, to take charge of this new work in Farm Mechanics. His efficiency he has already demonstrated, and the value of this work is now being realized and appreciated by the people of the state.

Colorado Seed Competition Club. Early in the spring, I sent out instructions to members of our seed competition club for seeding and asked that reports be sent in from time to time. These members numbered several hundred, well distributed over the grain growing sections of Colorado. The bad storms of last month delayed threshing operations and not all the members of the club had been able to thresh when this report was written. I hope to be able to get all reports so I can make the prize awards by December 1st. There will be $400.00 in prizes awarded for the 1906 crop, $400.00 for the 1907 crop, $400.00 for the 1908 crop, and $1,300.00 for the term premium awards in 1908. We hope to enlist the support of the rural teachers at the State Teachers' Association in December, and shall strive earnestly to increase the club to 1,000 members next year. I shall send out a New Year's letter urging each present member to bring in one additional member and plan to make the best possible record with our grains for 1907.

Farm Institute Work. It has been my privilege to assist in Farm Institute Work in the following counties: Arapahoe, Bent, Boulder, Delta, Elbert, El Paso, Conejos, Fremont, Gunnison, Kit Carson, La Plata, Logan, Mesa, Montezuma, Montrose, Otero, Prowers, Pueblo, Rio Grande, Routt and Weld.

I find considerable interest is shown in questions of cultural soil treatment to maintain, or regain and retain fertility, seed selection, the thorough tillage treatment and special crop discussions. I have tried to adapt my discussions to the crop and farm environments of the places where the institutes are held. I am certain a considerable influence of permanent value can be exerted by the Farm Institute movement, looking to better systems of crop and live stock farming in our state.

Correspondence. My correspondence is increasing, but I believe it is to be encouraged if we expect to come in touch with farmers in the state. I want every farmer to feel perfectly free to write me on any farm question and to know that his letter will receive careful consideration in a prompt, ready and courteous reply. I have a plan for a crop correspondence system in connection with my Department which, if adopted, will enable us to receive accurate crop statistical data. Some system is now in operation in all the agricultural states and is the source of reliable information as to the number and kind of crops grown, yield and value, market conditions, etc. This plan I will carefully outline and explain to you before January 1st.

Course of Study. The course of study agreed upon for 1906-'07 was printed in the regular course of study. The only changes I would like to see made I enumerate below:

1. Freshman Year—The time for laboratory work in Spring Term Farm Mechanics extended two hours per week and each student in the Agricultural Course taught to run land levels.

2. Senior Agronomy work in the Fall to consist in research work in Tillage and Cultural Methods of Crop Farming. In the Winter Term, lectures in Agricultural Economics; Spring Term work, Senior year, Research work and class lectures in Farm Management.

I would like very much to have the following post graduate work indicated in the new year's catalogue:

I. The Thorough Tillage System of Farming.
II. Grain Judging.
III. Special Studies in Field Crops.
    1. Forage Crops for Colorado.
    2. Sugar Beets.
    3. Wheat.
    4. Oats.
    5. Barley.
    6. Seed Testing and Germination.
    7. Plant Breeding as applied to Field Crops.
    8. Study of past and present Market Conditions.
    9. Rotation of Crops.

IV. Farm Management.

1. Special versus Mixed Farming.
2. Crop Methods for Irrigated Farming.
3. A Method of Farm Accounts.
4. Handling Labor on the Farm.
5. Extensive versus Intensive Farming.

New Assistant Needed. The teaching work is increasing to such an extent that I feel, before another year, I shall need an assistant to take some of the class instruction work in both the Long and Short Courses. I would suggest that we secure one of Dr. Hilgard's students who has made a careful study of soils in both the arid and humid regions, and who will be prepared to also do the chemical work of both the Animal Husbandry and Agronomy sections of the Station when not engaged in class room instruction.

My plan is to organize the Soils into a department as soon as we get an assistant of sufficient ability, force and experience to carry the work.

The study of the soil is the foundation work in all successful crop farming. My work is increasing to such an extent that I feel I must, another year, have an assistant to carry a part of my class work. I would prefer one thoroughly prepared in Soil Study work, so we can make the division of the Agronomy work along this line later on.

Recommendation of Mr. Knorr. Dr. Aylesworth promised to ask the Board at the June meeting, to advance Mr. Knorr's salary from $600 to $800 per year. He told me later that the Board agreed to advance Mr. Knorr's salary to $800 beginning November 1st. Because of the increased amount of class instruction and laboratory work which I am forced to give Mr. Knorr in addition to his field work, I desire arrangements made at the December meeting to advance Mr. Knorr's salary, after graduation, to $1,200, and that he be made Assistant Professor of Agronomy. He is one of the most practical and thoroughly efficient young men in agricultural work, and unless we recognize his ability and plan *now* for his advancement, I fear we shall lose him, later on. He was offered desirable positions this past summer elsewhere, but I told him if he would stay with us we would take care of him and give him merited promotion.

My field work at the College is broadening and I need his help in the College work as well as in the field station work. Kindly present this matter for me at the December meeting, or at such a time as you may think most opportune.

Special Needs. There are some special needs in the way of apparatus and room which I wish to name in a special report later on. There are calls coming in for special farm management work and Mr. Knorr and myself desire to be prepared to give the desired instruction. We seek to make our instruction

in Agronomy as practical and thorough as possible, so students shall feel it helpful in fitting themselves for farm work under western conditions.

I am grateful to you for the many courtesies which you have extended to me during the year just closing.

Respectfully submitted,

W. H. OLIN,
Professor of Agronomy.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DIVISION OF ANIMAL HUSBANDRY OF THE AGRICULTURAL DEPARTMENT.

Professor W. L. Carlyle,
Dean of Agriculture,
Colorado Agricultural College.

Dear Sir—I herewith submit a report of my work in Animal Husbandry and a statement of plans and needs for the future:

I began work September 1, 1906, and October 1, 1906, you engaged W. H. Riddell, a graduate of this College, Class of 1906, as my Assistant.

I have taught four classes during the Fall Term of 1906:

Senior Class in Feeds and Feeding.

Junior Class in Feeds and Feeding.

Sophomore Class in Breeds of Live Stock.

Sophomore Class in Judging Live Stock.

During the three months that I have been connected with the College I have made three trips, of a week to ten days each, on Farmers' Institute work. At present, one student, W. H. Riddell, is taking post graduate work under my direction, in feeding.

We have fairly representative pure bred animals of most of the leading breeds of beef and dairy cattle, sheep and hogs. We need for class work in the study of breeds, Galloway and Jersey cattle, and Duroc Jersey hogs.

Our great need for efficient, practical instruction is in feeding animals and in feeding operations. The feeds and climate of Colorado are particularly adapted for the production of meat of the highest quality, and when Colorado stockmen become feeders the State will be noted for its large production of animals fattened on Colorado grown feeds, and the meat from these, on account of its superior flavor, will command a higher price than that from the corn belt.

The College should feed on a commercial scale, to enable our students to obtain a practical knowledge not only of the effect of different feeds, but of how to handle and manage stock on a money making basis. They cannot learn this from feeding small lots. We should feed cattle, hogs and sheep in carload lots, and have a sufficient number of carloads of each class to teach our students to be able to judge and select feeding animals on a carload basis, as a means of making a living that will be worth many times to them the studying and judging of a few choice pure bred animals.

For this purpose I recommend that the College feed each year ten carloads of beef cattle, raise and fatten each year one thousand hogs and feed two thousand sheep. The feeding should be conducted to make money. The work should all be done by students working under the direction of the Professor of Animal Husbandry. With such a system of four years of practical work in feeding, coupled with thorough theoretical work in the class room, our students would graduate ready to profitably operate feeding plants and would become leaders among our stockmen.

Few States have as favorable conditions for profitable poultry production as Colorado, yet the entire yearly poultry products marketed in the State will not supply Denver alone for more than sixty days, and one million and a half dollars' worth of poultry was shipped into Colorado the past year. Colorado should not only produce all poultry and eggs needed in the State, but should and could profitably ship several million dollars' worth each year to other States.

The Colorado Agricultural College should keep one thousand hens and produce on a commercial scale eggs, broilers, roasters, turkeys, ducks and geese. In connection with this work, we should establish a course in poultry raising and furnish an opportunity to every boy and girl in the State to learn how to hatch fowls the natural way and by incubators, and the feeding, breeding, fattening and marketing of poultry.

Respectfully submitted,

H. M. COTTRELL,

Professor of Animal Husbandry.

Fort Collins, Colorado, November 30, 1906.

REPORT OF THE DIVISION OF FARM MECHANICS OF THE AGRICULTURAL DEPARTMENT.

Prof. W. L. Carlyle, Dean of Agriculture, Colorado Agricultural College.

Dear Sir—I hereby submit plans for work which I believe advisable to carry out in the Farm Mechanics Department of the Colorado Agricultural College in the future.

While Farm Mechanics has been taught, to a limited extent, in connection with the Agronomy Department for the past two years, it has been organized as a separate Department since July 1st of this year. I arrived here from the Iowa State College the last of June to begin work organizing this new Department.

Shortly after arriving here, I accompanied a party of Farmers' Institute workers to the Western Slope for the purpose of obtaining information as to various state conditions. Since that time I have made several visits to various parts of the state for the same purpose. The remainder of the summer was spent organizing the work of the Department and securing machinery for instructional and experimental purposes.

For the reason that the Department is just being organized, there was no arrangement made for classes according to the College catalogue, other than the work taken up under the Agronomy Department last year. The work as outlined in the present catalogue for the regular course in Agriculture takes up the following:

Freshmen—Woodwork—Fall Term.

Freshmen—Iron Work—Winter Term.

Freshmen—Farm Machinery—Spring Term.

Farmers' Three Months Short Course:

First Year—Farm Machinery, three weeks—Second Term.

Second Year—Farm Mechanics—First Term.

During the first one-half of the present Fall term a special class has been organized in "Farm Motors," consisting of Seniors and Juniors in the Agricultural Course. The larger part of this class are continuing this work for the remainder of this term.

For next year I recommend that we take up the following class work:

Freshmen—Woodwork—Fall Term.

Freshmen—Iron Work—Winter Term.

Freshmen—Farm Machinery—Spring Term.

Sophomores—Rural Architecture—Winter Term.

Juniors—Farm Motors—Fall Term.

Seniors—Special Farm Mechanics—Spring Term.

Farmers' Three Months' Short Course:

First Year—Farm Mechanics—Second Term.

Second Year—Farm Motors—First Term.

Up to the present time we have been able to secure about $12,500.00 worth of farm machinery for experimental and demonstration purposes. This machinery has cost us nothing more than the freight charges from the nearest general agency of the manufacturer to Fort Collins. We will be able to secure several thousand dollars' worth more of sample implements and machines at no more cost than the above, providing we are furnished with enough funds to cover freight charges. Owing to the fact that implement companies are really asking us for an opportunity to place with us sample goods and that our shed room is very limited, it will be necessary to secure funds for more storage room in the very near future. There is no reason why the student who comes here from the farm, as well as the many interested visitors, should not be able to see well kept sample implements and machinery in this department. For this purpose we need room enough for at least $50,000.00 worth of farm machinery.

On account of not being provided with funds for experimental purposes, it is very difficult to outline work of this kind. We have, however, started some investigation work in the following lines, and expect to carry it out as rapidly as the necessary funds can be secured.

Pumping Plant. The College has agreed to furnish material for causing a well and equipping it to develop additional water supply for the College Farm and for an experimental pumping plant. We expect to dig this well on the College grounds with farm help. We now have a pump and have been able to secure a gasoline engine for power purposes, which can be used in connection with this work. This investigation is for the purpose of ascertaining the cost of lifting the water by gasoline, kerosene or denaturized alcohol; also to determine the amount of water necessary for the growth of certain crops and to gain general information regarding this method of securing water. We believe it also advisable to visit various pumping plants throughout the state for the purpose of securing general information in regard to equipment, arrangement, cost, practicability, etc.

Gasoline Engines. On account of the passage of the bill on denaturized alcohol, we believe it advisable to do experimental work with alcohol, comparing it with gasoline and kerosene. At the present time we are conducting a test comparing kerosene and gasoline for power purposes in the gasoline engine. For this purpose we now have seven gasoline engines.

Steam Plowing. Having secured a 25 H. P. Traction Steam Engine, equipped with eighteen plows, we believe it advisable to make investigation concerning the question of steam plowing, its cost, etc. In connection with this work we are anxious to secure such facts and information as may be obtained from various plowing outfits over the state and to place the data thus obtained so that it will be of value to the general public.

Draft Tests. We find that similar implements of different manufacturers vary greatly in the amount of power necessary to operate them. For the purpose of making comparative draft tests we have secured the use of a German Dynamometer from the U. S. Government.

Special. At the present time we have two manufacturers of grain drills making special drills for use under "Dry Farming" conditions.

Another company manufacturing Grain Graders have made us a special grader for grading beet seed, alfalfa seed and various small grains. We believe that the beet seed grading attachment will be of special value to the Sugar Beet Industry. Uniform sized seeds planted in check with a special planter so the beets can be cultivated both ways will certainly aid in the cost of beet production. By uniform size of seed, two can be dropped in each hill, and in case both seeds grow, one plant can easily be removed. Thus the question of beet thinning will be made less expensive.

We also desire to make special study and investigation of beet cultivators, pullers and toppers.

Still another field open for investigation is the "Use of Cement on the Farm," which we desire to take up.

Respectfully submitted,

H. M. BAINER,
Professor of Farm Mechanics.

Fort Collins, Colorado, November 7, 1906.

REPORT OF THE FARMERS' INSTITUTE DIVISION OF AGRICULTURAL DEPARTMENT.

Professor W. L. Carlyle,

Dean of Agriculture,

Fort Collins, Colorado.

Dear Sir—I have the following report to make as Director of Farmers' Institutes. This report covers the period from August 1st, 1905, to November 1st, 1906, and also covering practically all of the institute work that has been done since my appointment as Director.

The total number of Institutes held were 48; total number of sessions, 152; total attendance, 18,615; number of speakers employed from College Faculty, 16; speakers employed outside of the College, 10. With the exception of a few scattering counties in the Eastern part of the State which are as yet very thinly settled, Institutes have been held in practically all of the Agricultural counties of the State and in some of the counties covering large areas several Institutes have been held.

As regular Farmers' Institute work was new to the majority of our agricultural population, our first year's work has been largely of an introductory nature. This is necessarily more expensive work, as it involves sending out enough speakers to practically occupy all of the time of the Institute.

Commencing this fall we have very materially reduced the number of workers sent to each Institute and are seeking to place the work upon a more practical basis by limiting the number of subjects to be discussed and exhausting those subjects thoroughly. Eleven Institutes are being held during the present month, which will conclude our Institute work for the present year, as the Short Course at the Agricultural College, in December, followed by the holidays, will occupy all the time of the men who might be employed in the Institute work.

The cost of the work up to November 1st has been approximately $5,500.00, leaving a balance of about $2,500.00 to pay the cost of the Institute work this fall and early spring. In estimating the attendance at the Institutes, it has in most instances, been based upon count of the number attending the various sessions. During the past year we have succeeded in developing some local talent that can be used to good advantage in the future for Institute work in the field. We should have an appropriation for the ensuing two years of at least $10,000.00 and in the future the work should be confined to those localities expressing a desire for the Institute work. During the past two years we have, in a measure, forced the Institute work upon the people, as we were

compelled to introduce it. Now that the nature of the work is understood, however, I would recommend that Institutes in the future be given only when the people of any locality express enough interest in the work to request one.

By this method some localities will probably secure more Institutes than others, but this can not be avoided. It has been my policy to encourage the holding of Institutes wherever the people are inclined to show any interest whatever in the work.

In suggesting the increased appropriation for the ensuing two years, I do so under the idea that, in the future, members, of the Agricultural Faculty will be unable to give as much time to this work as they have during the past year, owing to the increased attendance at the Agricultural College. This will make it necessary to engage outside workers as other States do, and will necessitate larger expenditures. As a rule where the Institute has been well atended the effect has been good and there seems to be a general demand that the work be continued during the coming two years, provided funds can be secured from the Legislature. I am assured that we will have the co-operation of the farmers and stockmen generally in the securing of such an appropriation as may be necessary. Our ability to cover the large territory that we have and to hold so many Institutes on the small amount of money appropriated, is due to the liberal assistance provided by the railroads, which have generously provided transportation for our workers on practically all occasions, only one railroad having denied this assistance, and in that case half rate was secured. We have reason to hope that this assistance from the railroads will be continued.

At all of the Institutes we have made it a rule to very thoroughly describe the educational work being done at the Agricultural College and the advantages to be had by young men and women in taking an Agricultural Course at the College. We have also endeavored to interest farmers' wives and daughters in the work, and the attendance at all of the Institutes has been about equally divided between men and women. At many points we have been able to hold special sessions devoted to the women entirely, and as a rule we have found them very effective and popular. I believe that the results obtained from the Institutes already held during the period of this report have unquestionably been of great benefit to Agriculture in the State. The continuation of the work can not fail to bring the same benefits to Agriculture in Colorado that have been secured in other States where Institute work was not only new to the Agriculturists of the State, but also to the men and women from the College and elsewhere, who engaged in the work. I feel that we should be congratulated upon the complete success so far attained.

Very truly yours,

FRED P. JOHNSON,
Director of Institutes.

REPORT OF THE DEPARTMENT OF HORTICULTURE AND BOTANY.

To The State Board of Agriculture.

Gentlemen—I have the honor to present the following report of the Department of Horticulture and Botany for the year 1906.

There have been a number of changes in the personnel of the force of the Department during the past year. Prof. O. B. Whipple was transferred in April to the western part of the State, where he has charge of the Western Slope Fruit Investigations. Mr. E. R. Bennett came to us to take charge of the potato investigations in April, Prof. L. M. Paull was secured to take the place left by Mr. Whipple and assumed his duties at the beginning of the present school year. It will thus be seen that the Department has been materially strengthened and its work broadened.

The work of instruction has gone according to the schedule and the interest has been good. There are some changes in the course of study, however, which we hope to see adopted by the next school year.

FRUIT GROWERS' SHORT COURSE.

Arrangements are progressing satisfactorily for the Fruit Growers' Short Course which is to be held in Delta, beginning January 14th and continuing one week. The citizens of Delta County have taken an active interest in the school and give assurance of a large attendance.

WESTERN SLOPE FRUIT INVESTIGATIONS.

This work, which you authorized at your last December meeting, was duly inaugurated last spring. Mr. E. P. Taylor, a graduate of this College, was appointed Entomologist, and O. B. Whipple, formerly assistant in this department, Horticulturist. Their reports will appear elsewhere, but I may say here that the results have far exceeded our expectations. The calls that came to these men by mail and telephone requesting visits of inspection would have taken all of their time had they been fully met. But a number of experiments were undertaken and results have been attained which should be of much value to the fruit growers.

POTATO INVESTIGATIONS.

The importance of the potato crop in the State seemed to warrant the employment of an expert to devote his entire time to its study. The problems concerned are of such a nature that several years must elapse before much can be accomplished. A good start has been made with the work and a number of leading experiments have been outlined for next season.

EQUIPMENT.

The Department is now very well equipped with apparatus. In former reports I have mentioned our needs in the way of new greenhouses and suitable land for orchard purposes. These needs are still urgent.

The development which the Department has undergone in recent years is certainly gratifying to me and I therefore wish to express my appreciation of the liberality and fairness with which my requests of the Board have always been met.

Respectfully submitted,

W. PADDOCK,
Professor of Horticulture and Botany.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF MECHANICAL ENGINEERING.

To The State Board of Agriculture:

Gentlemen—I have the honor to submit herewith the annual report of the Department of Mechanical Engineering.

The students in the first and second Sub-freshman years have received instruction in wood working, being taught the ordinary bench work of the carpenter. This is all the departmental work these students get until they reach the Freshman year.

The Freshman students have received instruction in drafting and bench work in wood and, in connection with their shop work, have had text book work bearing upon the subject.

The Sophomores have received instruction in machine drawing, workshop appliances, machine design and special machines. Their shop work has consisted of training in wood turning and pattern making.

The Juniors have taken up the subjects of machine design, principles of mechanism, steam boilers, steam engines, metallurgy and pumping machinery. Their shop work has been in the foundry.

The Seniors have received instruction in gas and oil engines, steam engine design, transmission of power, thermo-dynamics, compressed air machinery, heating and ventilation, railway mechanical engineering, contracts and specifications.

All the work has been accomplished, and, we believe, with direct benefit to those students who have profited by their opportunities. We have used modern methods in the classrooms, laboratories and shops, and while students have much to learn after leaving college, we are confident they will not have to learn over again what has been taught them. The industrial prosperity and activity of the country calls for large numbers of young men trained along mechanical lines and this demand promises to be long continued. The young men from this Institution are measuring up to the requirements of the times and are to be found in many places of responsibility and trust.

The rapid advance in the improvement of methods and machinery has brought about many changes. High steam pressures are calling for stronger and better boilers, and this in turn calls for better steel. Improved tool steels have called for changes in the design and construction of machines and these new machines are capable of turning out work much more rapidly than ever before. The electric drive has been put to many uses not thought of a few years ago, and has a general tendency to hurry up things.

Great discoveries and the rush of modern methods is calling for more from the young men in the way of knowledge of things and affairs, and this Department has tried to keep up with the world's work in the lines required of us, and if the evidence of those students who have made a success of their work counts, then we have done it.

We believe the work of the Department is in line with that of the best schools of the kind, and that our graduates are able to hold their own.

Respectfully submitted,

J. W. LAWRENCE,

Professor of Mechanical Engineering.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF CIVIL AND IRRIGATION ENGINEERING.

To The State Board of Agriculture:

Gentlemen—I have the honor to present the annual report of the Department of Civil and Irrigation Engineering for the past year.

The work of the Department has been hampered by lack of room. The present quarters were outgrown a good many years ago. Though the quarters were a convenience at the time this building, the oldest one on the grounds, was assigned to this Department some twelve years ago, they were even then inadequate, because of lack of laboratory facilities and for instruction in matters relating to irrigation and hydraulics, which requires much more laboratory room. It would have proven entirely inadequate except for the fact that the fields, ditches and reservoirs, streams and mountains of the surrounding country have been used to a great extent as a part of our laboratory equipment. There are more enterprises of this character and more illustrations or irrigation work within a moderate distance of Fort Collins than in any other center. The lack of laboratory room, therefore, forces more attention to outside work, but from the standpoint of teaching, this course has very serious disadvantages. The progress of this State depends so largely upon water that questions of this character are of great importance, but we cannot do what we should, either for our students of for the State without greater facilities of this kind. The requirements of teaching and all pro grams for recitations do not readily lend themselves to the use of laboratories which may be several miles away. The lack of room has been seriously felt. In the lack of class rooms a make-shift has had to be made to find recitation rooms. Likewise the drafting room has been a make-shift, and moderate sized classes have made it necessary to overflow into adjacent rooms at great inconvenience, as well as under conditions that are not possible for the best work. The fact that we have reached the capacity of the building for instruction has stood in the way of increasing the number of students, although there has been a steady growth.

With the lapse of years there has also been a steady cause of anxiety in the increasing dilapidation of this building. The foundation has settled and the walls have cracked seriously. It is a frequent question as to the safety of the building. Manifestly it cannot be considered as a safe structure for many years longer. If it should be that it is necessary to still occupy this building for some time in the future, I should recommend the construction of an addition or some temporary structure, even a tent, to meet the necessity of additional room. That this building occupies a

central position on the grounds has made us hesitate to recommend temporary additions, unless they could be so built as to be pleasing to the eye. At the same time our necessities are increasing and we must have additional room.

This Department was organized and the course in Irrigation Engineering established in 1890. There had been a Department of Physics and Engineering established in 1887, with Prof. Elwood Mead in charge, and with his resignation in February, 1888, the present head succeeded him. Physics remained attached to the department until 1905.

The Board had recognized from the first the importance which Irrigation and Irrigation Development played in the State and in all the Western States, and that instruction in it was fundamental to the general welfare of the State. It was at their desire and upon their motion, that the original step was taken toward instruction in Irrigation and the establishment of the course in 1890. This was the first course of the kind in this country, and that it has been useful is shown by the record of its students. Since that time many other Institutions have followed this lead and have established courses especially strong in Hydraulics and in Irrigation Engineering, and even eastern schools are giving instruction in this branch. Even from the agricultural standpoint it is recognized that such engineering is the fundamental part of western Agriculture. The eternal problem is to increase the production of our soils, or to render them capable of production. The most necessary element for a plant to obtain is water. In the humid climates of the east this is supplied by the climate, and the problem there becomes largely one of obtaining other elements and the study of chemistry becomes most important. In this region, in the absence of sufficient rainfall, the primary need is for water. The obtaining of water and bringing it to the land is an engineering question, and consequently we find that engineering is of corresponding importance in the west, although not recognized in the east as a part of Agriculture.

The general intent of the Board seems to have been to cover in this course some of the questions relating to Agricultural Engineering, and these have been more or less closely associated. Instruction has been given in Roads, in Farm Irrigation, in Practical Irrigation and Agricultural Hydraulics. The general attempt is to so prepare our students that they shall be qualified to occupy positions of usefulness in the community and in the development of the State.

It is unnecessary to specify the separate studies which are shown in the course of study as given in the catalogue. It may, perhaps, be well to mention that some of these lines of work and study, which have been given in this Department for a number of years and so announced in the catalogue and planned for with the full approval of the Board, are announced by other

Departments of the College, thus making a duplication of work. If it be the intention of the Board that this duplication should exist, it is only proper that it should be clearly understood and expressed.

The work of a College such as this is largely judged in its collegiate work, by the character of the students we turn out and the benefit which they have received, and the training either in discipline or in special work. A number of years is required for a student to show his training and to find his place. Sometimes a good many years are required. It is always a matter of interest to observe the career of students, and so some record has been made from time to time of the work of former students, especially those who have had instruction along the line of irrigation. The following list is therefore only a partial one, showing the work of many of those who have had instruction in Irrigation Engineering. It is a list in which the College may take pride. The first figure being the year of their graduation, the first place being the place they came from. The list is incomplete. Many of those who have taken the course have gone into other occupations, some are dead, and the addresses and history of some have not been well known.

1892. C. W. Beach, Fort Collins. Graduated from the University of Illinois, 1893; special gaging work for the Colorado Experiment Station; mining surveyor, Victor; in charge of the river records and surveys for the Great Plains Storage Co., Lamar, from Twin Lakes to the State line, 1896-1904; Practicing engineer Arkansas Valley, in charge of considerable construction; Deputy State Engineer, 1905.

1892. Frank Beach, Fort Collins. Special student of the University of Nebraska; Supt. New Mexico Sub-Station at Las Vegas; Of the San Luis Valley Sub-Station, Monte Vista; Prof. of Agriculture and Irrigation Engineering, Montana Agricultural College; Farmer and County Surveyor, Las Animas; Farmer, Fort Collins.

1892. L. L. Stimson, Greeley. Special work for the Experiment Station, 1893; Practicing irrigation engineer, Greeley; County Surveyor of Weld County, several terms; City Engineer, Greeley; as such, had charge of the construction of extensive improvements to the city water works during his term; Surveyed and constructed many of the large reservoirs in Northern Colorado, the Jumbo, Empire, etc.

1892. Porter J. Preston, Longmont. In charge of canal rating and river gaging, State Engineer's office, 1893-'96; Engineer, Pawnee Pass Reservoir Co.; In charge of river service in the Arkansas Valley; Construction Engineer, Fort Lyon Canal enlargement; Supt. of the Fort Lyon

Canal (110 miles long), Las Animas, for several years; Deputy State Engineer, 1903-'04; Construction Engineer in charge of canal system and reservoir, Lewiston, Ia.

1893. J. D. Bloomfield, Meeker. Assistant in Irrigation Engineering Experiment Station, Irrigation Engineer, Greeley; Took charge of the Phyllis canal, Nampa, Idaho, organizing and making a financial success of it in 1894-1904; Cashier of the newly organized Citizens' State Bank, Nampa, Idaho.

1893. S. Boothroyd, Arkins. Assistant City Engineer, Fort Collins; Student at Chicago University; Professor at Mt. Morris College, Ill., and at Bellvue College, Nebraska; Assistant Astronomer Lowell Observatory, Flagstaff, Ariz.; Assistant Prof. Engineering, Fort Collins; Assistant Mechanics, Cornell University, Ithaca, N. Y.; Summers in charge of a party on the International boundary survey, between Alaska and Canada.

1893. R. F. Walter, Fort Collins. Irrigation Engineer for a number of years, at Greeley; County Surveyor, of Weld County; City Engineer, of Greeley; Planned and constructed many irrigation ditches and reservoirs, Engineer Reclamation Service 1902, and has been promoted to Division Engineer in charge of South Dakota, and as such is responsible for all surveys and construction of the Belle Fourche Project, S. D.

1895. J. B. Balcomb, Russell, Kan. Practicing mineral surveyor in Colorado, Engineer of various mines and in charge of various hydraulic constructions and mining work in Palo Alto, California.

1895. Henry Calkins, Harris. Assistant Civil Engineer, Molly Gibson Mine; Medical student, Denver; Practicing Physician, Leadville.

1895. E. P. Cooke, Dowagiac, Mich. From responsible position in Iowa, and now connected with the construction and supervision of a large power plant in California and Nevada.

1895. L. B. Curtis, Denver. For several years Assistant Engineer, having charge of the construction work of the Denver Tramway Co.; Engineer on hydraulic projects, including New Century Mining Company, at Gore Canon; Construction Engineer of 115 mile power transmission plant, from California to the Mining Camp of Nevada, making a record in construction.

1895. Geo. W. Nelson, Denver. Has been assistant Superintendent of mines at Grand Forks, B. C.

1896. H. F. Alps, Loveland. Assistant Meteorologist, Experiment Station, Fort Collins; Observer of the U. S. Weather Bureau, Nashville, Tenn.; Lewiston, Idaho, and Reno, Nevada.

1896. R. W. Hawley, Fort Collins. Assistant Supt. Nampa Canal, Idaho; Assistant Engineer of the Western Homestead Co., Albuquerque, N. M.; Assistant Irrigation Engineer for gaging in the Arkansas Valley for the Colorado Experiment Station; Gauger for the State Engineer's office, Denver; On topographical survey in the Reclamation Service, Supt. of the Carson Sink Canal, Carson City, Nevada.

1896. G. S. Norman (Colored), Hamilton, Ohio. Became 2nd Lieut. 8th Inf. in the Cuban war; Instructor in mathematics Bluegrass Normal and Industrial Institute, Keene, Ky.; Instructor in Mathematics and Agriculture, Agricultural and Mechanical College, Normal, Ala.

1896. R. W. Sears, Rye, Colo. Principally associated with stock interests, though also with some irrigation developments.

1897. A. J. Harris, Fort Collins. Entered the regular army as 2nd Lieut. during the Cuban war, Promoted to Captain —— Inf., stationed at the Philippine Islands.

1897. R. S. Gray, Wyoming. In public Service in the P. I., Deputy Division Supt. of Education, Iligan, P. I.

1897. D. J. Richards, Salida. Enlisted during the Spanish war, in public service, since Deputy Post Master, Manila, P. I.

1898. H. O. Brown, Salida. In business with his father and then on the Engineering corps of the D. & R. G. Ry.; Now Engineer, Los Angeles, California.

1898. R. C. Calloway, Livermore. Foreman of the College farm, Fort Collins; Farmer, Bellevue, Washington.

1898. F. S. Hotchkiss, Hotchkiss. Farmer and Irrigation Engineer, Hotchkiss, Colorado.

1898. Amos Jones, Canon City. Assistant Engineer Crystal River Railway; Assistant in Engineering, Agricultural College, Fort Collins; Entered Reclamation Service in charge of topographical surveys in Nevada; Special Deputy from the State Engineer's office in charge of Arkansas River distribution; Civil Engineer, Stockton, California.

1898. C. E. Swan, Delta. Has been connected with the Engineering Department of the U. P. Coal Company, Rock Springs, Wyo., from a short time after graduation. Now

is principal assistant engineer and has charge of the surveys of many mines in Wyoming and Colorado.

1898. M. D. Williams, Victor. Assistant Engineer, West Galla tin Irrigation Co., Montana; On the Short Line Railroad Survey; Pike's Peak Power Co., where he met with a serious accident; Especial work in the Experiment Station at Fort Collins; Engineer of the Kuykendall Co., Saratoga, Wyo.; In stream gaging and survey with the U. S. Reclamation Service, Arizona and Oregon; Practicing Irrigation Engineer, Klamath Falls, Oregon.

1899. Frank Corbin, Fort Collins. Succeeded to his father's interest in business in the firm of Corbin-Black Lumber Co., Fort Collins.

1899. N. M. Fitch, Denver. Has been in the engineering party of the railroads in Texas and Missouri since graduation, and is now resident engineer of the T. & O. Ry., Ada, Indian Territory.

1899. L. C. Hall, Canon City. City Engineer, Canon City, in charge of extensive sewer improvements.

1899. W. R. Headden, Fort Collins. In the Director's office of the Experiment Station; Graduated from Renssalaer Polytechnic Institute, Troy, N. Y., and is now an instructor therein.

1899. J. C. Mulder, Holland. Entered the Civil Service and is now Provincial Supervisor, Province of Bohol Tagbilaran, P. I.

1900. J. A. Stump, Canon City. Instructor in the Engineering Department of this College for several years, then a student of law at Ann Arbor and is now a practicing attorney at Canon City.

1900. T. M. Donelson, ————————. Principally in engineering parties on railroad work and now assistant engineer on the Mexican Central Railroad at Aguas Calientes, Mexico.

1900. E. C. McAnally, Fort Collins. Has been county surveyor of Larimer county and City Engineer of Fort Collins for several terms. Constructed the scenic road up the Big Thompson Canon to Estes Park; also had charge of the construction of the Fort Collins water works, which cost over $200,000.

1901. Jas. H. Andrews, Fort Collins. Student at Columbia University, N. Y. In charge of location surveys on the Grand River canal at Lulu Pass; In charge of the trestle and sewer work for the Great Western Sugar Company at Fort Collins in 1905; in charge of extensive railway improve-

ments on the C. & S. between Longmont and Fort Collins; Instructor in Department of Civil Engineering, Fort Collins, and post-graduate student 1906.

1901. A. Jacob, Antonito. Assistant in stream gaging and seepage measurements for the Experiment Station; On the Engineering force of the Great Plains Co., at Lamar; Assistant in the State Engineer's office 1903-4; Practicing Engineering, Denver.

1901. G. B. Stannard, Fort Collins. Assistant Engineer in the coal mine surveys of the Colorado Fuel & Iron Company for a number of years. Now a practicing engineer in Denver.

1902. L. E. Cattell, Ohio. Has been steadily in railroad employment in engineering parties in Ohio since graduation.

1902. Oro McDermith, ————. Fellowship in the Agricultural College, and also served as instructor. Assistant in the U. S. Reclamation Service stream gaging and topographic surveys; now in charge of one heading of the Gunnison Tunnel, Montrose, Colorado.

1902. Oliver Pennock, Bellvue, Colo. Assistant in surveys for Mr. J. C. Ulrich on the Grand Valley Canal at Lulu Pass. Permanent address, Bellvue, Colo.

1902. R. E. Richardson, ————. Assistant in special work of the Experiment Station; Assistant Engineer on the construction of Lake Reservoir for the C. F. & I. Co., at Leadville; Practicing Engineer, Delta; Surveyor and practicing engineer, Longmont.

1902. Harry True, Nepesta. Had a fellowship and acted as instructor in the Agricultural College; Assistant in stream measurement State Engineer's office, Denver; Assistant Engineer Panama Canal, under Civil Service, in 1905-06; On reservoir surveys at Sterling.

1903. C. E. Davis, Canon City. Deputy City Engineer, Canon City.

1903. D. D. Gross, Greeley. Draftsman in the Engineer's office of the Denver Union Water Company, Denver.

1903. R. P. Jackson, Denver. Principal assistant in the State Engineer's office 1903-05; Now in the Engineering force of the American Smelting Co., Salt Lake City.

1903. W. A. Lamb, ————. Assistant in gaging for the Experiment Station; Assistant in stream gaging U. S. Reclamation Service in Northwestern Colorado; Now permanently connected with the U. S. Reclamation Service.

1903. R. C. Murphy, Glenwood Springs. Surveyor at Glenwood Springs.

1903. J. A. Phillips, Fort Collins. In the engineering party on the Grand River Canal; With the Great Western Sugar Company at Fort Collins and Longmont in the development of lime quarries.

1904. H. V. Hubbell, Fort Collins. Assistant to the Consulting Engineer for Colorado in the Kansas-Colorado suit, in charge of stream measurements in Kansas 1903-04; In gaging near Pike's Peak in 1905; Irrigation Engineer, Longmont, and now Engineer on the Western Pacific Ry., in Utah.

1904. Ralph Parshall, Golden. Instructor in the Agricultural College; Charge of survey of a railroad now constructed in the Arkansas Valley; In charge of the students' Field Camp in 1905 and 1906.

1904. Howard Sneddon, Salida. In charge of gaging on the upper Arkansas River for the Consulting Engineer for Colorado in the Kansas-Colorado suit; Now a railroad engineer in New Mexico.

1905. P. J. Mulder, Holland. Engineer for the ——— ——— Company, in charge of construction of a dam near Portland, Oregon.

1906. R. L. Cooper, New Windsor. On surveys for the Great Plains Company at Lamar.

1906. J. C. Counter, Brighton. On surveys of reservoirs near Julesburg, Colorado; Now Engineer for the North Poudre Irrigation Co., Fort Collins.

1906. Geo. M. Neel, Greeley. Assistant Engineer Central Colorado Power Co., Boulder, Colo.

1906. Littell Snively, ————. Engineer for the North Poudre Irrigation Company, Fort Collins and Wellington; Appointed Assistant Engineer U. S. Government, under Civil Service October, 1906, for service in the Philippine Islands.

G. L. Swendsen, a graduate of Harvard College, took special instruction in the summer of 1898. Professor of Engineering in the Utah Agricultural College; in charge of the Utah division of the Reclamation Service, and now Division Engineer, Salt Lake City.

E. P. Sandsten, from Wisconsin, a graduate of the University of Wisconsin, took part in some water and crop development in Minnesota and Wisconsin. Now in the Wisconsin Experiment Station.

Field instruction through the Field Camp still occupies its high place in our estimation as a desirable part of the training, as it has in past years.

For this purpose the students in this course are required to return to us in the fall two weeks earlier than other students, and spend that time in field instruction in the mountains. Under the rearrangement of the course every student will take three such trips. The camp this fall had nearly thirty. The main camp was made on the margin of Estes Park, and the work consisted of surveying a reservoir site with an inlet canal from Fall River. The Sophomores and Juniors composed this party. A portion of the inlet canal was through very precipitous country that could scarcely be traversed, and conditions were good for excellent training.

The Seniors formed a separate camp on the western slope under the instruction of Prof. House. Their camp used Grand Lake as a base of supplies, and their work consisted of running triangulation for a tunnel from Grand River to Estes Park, which would require a tunnel of about eleven miles. A great deal of the work was above timber line and consisted of severe and trying work. In this, as in all instances, the students have shown great zest and willingness to stand privations with alacrity, and ability to do work of a high order.

Each student pays the principal part of his expenses, though the expense has been more than has been thought best to assess. The instruction corresponding in that respect to laboratory work in the various laboratories of the College, which require an outlay for material as well as for the time of the instructors.

Previous classes have made surveys of reservoir sites, also have run lines of levels to the top of Long's Peak, have surveyed reservoir sites both on the Big Thompson and Fall River, which surveys have subsequently been used as the basis of filings by the owners of the land.

We have so far chosen Estes Park as the principal place for our work, because it has the greatest number of conveniences for this purpose. It is far enough from the College for the work to be isolated from such distracting influences, it has regular lines of communication, daily mail and express service, telephone, grocery stores available to supplement our commissary supplies, and from the standpoint of our responsibility an important point is that it has medical service to be called upon in case of necessity. So far in the years which the Field Camp has been continued we have had no accident, and no occasion for medical service, except for minor cases that may arise from camp fare.

Other places have been under consideration from time to time, but so far we have not found it best to make a change. With the growth of the size of the camp party, which has been the case during the past few years and is likely to be in the

coming years, some other arrangements are probably desirable. Thus the extreme limit of our equipment is for about thirty to thirty-five. The indications are that this coming fall we shall need to prepare for forty-five and possibly fifty. This not only requires addition to our equipment, but the proposition becomes an increasingly difficult problem and increasingly expensive. It, therefore, is a question if it were not desirable for us to do as eastern institutions have found it necessary to do—that is, to purchase a small tract of land and there erect a central building which may be used as a mess hall, and leave the tents, stoves and permanent part of the outfit from year to year. The saving in transportation would pay a large part of such expense.

At the beginning of this fall term Prof. G. N. Houston, who had been connected with this department for the past two years, was offered the place of Professor of Engineering in the University of Arizona, and resigned his position here at the beginning of the term, and with the Field Camp just fairly started. The work of the Field Camp was continued very well with Mr. Ralph Parshall, who had been acting as instructor in surveying, and the students received excellent training. The department was assisted during the fall term by James H. Andrews, a graduate of the department in the class of 1901, and who has had responsible work in some of the important irrigation work in this section, also with the Great Western Sugar Company in charge of the work at the Fort Collins factory, also having had charge of the improvements on the C. & S. in northern Colorado. His work has been very acceptable.

The vacancy has been permanently filled by the appointment of Mr. Robert W. Gay, a graduate of the New York University, who has had a variety of field experience, also experience as an instructor in Lehigh University for several years, assistant to Prof. Mansfield Merriman, the head of the department of Engineering in that Institution, and a well known author of many valuable text books. Mr. Gay came to us at the end of the Fall term and took up active work with the beginning of the present term. The work of the Department has begun with the change with a great deal of promise. The students are as numerous as our facilities will permit, are enthusiastic, doing good work and with excellent results, and have also the feeling that there is not only opportunity to benefit themselves, but also to benefit the community.

Respectfully submitted,

L. G. CARPENTER,

Professor of Civil and Irrigation Engineering.

Fort Collins, Colorado, November 15, 1906.

L. G. Carpenter,

Professor Civil and Irrigation Engineering.

Dear Sir—I submit herewith the semi-annual report of the work done as Assistant Professor in the department of Irrigation Engineering. The summer was spent in the Grand Valley upon the investigation of the seepage problem in that valley.

On August 27th the start was made for the field camp at Estes Park, and two weeks were spent with the Senior Civil Engineers of this College. We were camped at timber line on the western slope of "Flat Top" and, although the weather conditions were not favorable, we succeeded in completing the triangulation of a line for a tunnel from Grand Lake in Middle Park to Willow Creek in Estes Park.

During the three months of the Fall Term just closed, the following classes have been taught:

Senior class in Hydraulics.

Junior class in Strength of Materials.

Sophomore class in Photography.

Senior Civil Seminar has also been under my direction.

The afternoon work in the Testing Laboratory was hampered on account of the delay in receiving the parts of the testing machine sent away for repairs; otherwise the work done by all the classes was good and fully up to the standard.

Respectfully submitted,

E. B. HOUSE,

Associate Prof. Irrigation Engineering.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY.

To The State Board of Agriculture.

Gentlemen—I have the honor to present the following report from the Department of Zoology and Entomology.

The subjects taught in this Department now are Elementary Physiology, Advanced Physiology, Elementary Entomology, Advanced Entomology, Animal Parasites, Histology, Embryology and Evolution of Animals.

The Elementary Physiology is given to all first year preparatory students who do not have passing grades in this subject from accredited high schools.

The Advanced Physiology is taught to the Sophmores of the Agricultural, Horticultural and Domestic Science Courses, and to the Seniors of the Normal Course.

The afternoon laboratory work which used to be given with the Physiology was cut out when the Veterinary Course was introduced. While this is all right for the young men, some arrangement should be made for laboratory work for the women.

Zoology is taught to the students in the Agricultural and Domestic Science Courses. A special effort is made to give the student a good general knowledge of the important types of structure, and the development of the various organs and tissues found in animal bodies, and also to show the relations that exist between these organisms and their environment.

Entomology deals with the insect world and is only required of those students that take the Agricultural or Horticultural Courses. The first term in this subject is practical in its aims, only so much of the structure and general life habits being given as is necessary for an intelligent use of remedies and preventative measures. Two terms of advanced work are also offered to those students who wish to specialize along the lines of either economic or systematic Entomology. So far, the Department has not been able to supply the demands for trained Entomologists and those who have taken our advanced work in Entomology have been quickly picked up to fill positions in various parts of the country. The large systematic collection of insects, and the good scientific library that we now have, are an essential basis for this work.

The lectures to Juniors in the Agricultural and Horticultural Courses upon Animal Parasites, deal with economic species that attack domestic animals either externally or internally, the habits, symptoms and remedies being given in each case.

Histology, which is a study of the tissues of the body, is also taught to the students taking the Agricultural and Horticultural

Courses. So far as possible, the student is taught to prepare the tissues he examines, but the Department has on hand a large variety of tissues in permanent mounts for students' use. The subject is a most interesting as well as a most necessary one for a proper understanding of the organs composing animal bodies.

The lectures in Embryology to Seniors of the Agricultural and Horticultural Courses aim chiefly at laying a foundation for the understanding of the laws of heredity, while they also give a general idea of the first steps in the development of all animals, beginning with the process of maturation and fertilization.

The lectures upon Evolution (or development) of animals are given in the Senior year as a sort of fitting climax to what has gone before in this Department. The theory of Evolution as propounded by Darwin, with the evidence for and against it, and the laws of heredity and variation are discussed, and to make the lectures more easily understood, they are illustrated with numerous lantern slides.

MUSEUM.

The College Museum is now in roomy quarters, but, for lack of funds with which to obtain specimens, it grows very slowly. The recent purchase of over 100 pieces of pottery from the Cliff Dwellings of Montezuma County is by far the finest single acquisition that the museum has had for a long time. The museum collections are unduly crowded now for want of sufficient case room. Mr. L. C. Bragg is in special charge of the museum, and has added many specimens from his own collecting during the year, but I have had to keep him busy in entomological work much of the time.

OUTSIDE WORK.

Much of the time of the head of the Department is required in attending Farmers' Institutes and Horticultural meetings, and in investigating insect depredations in the State. As a result, it has become necessary to throw the teaching of the Department more and more upon the first assistant, Mr. S. A. Johnson.

The work of Miss Palmer as artist in this Department is extremely helpful, especially in my study of injurious insects.

Very respectfully submitted,

C. P. GILLETTE,

Professor of Zoology and Entomology.

Fort Collins, Colorado, November 8, 1906.

REPORT OF THE DEPARTMENT OF CHEMISTRY AND GEOLOGY.

To the State Board of Agriculture.

Gentlemen—I have, in compliance with the requirements of the State Board of Agriculture, the honor to present the following statement of the doings of the Department of Chemistry and Geology since my last report and of its present condition.

The teaching required of the Department has materially increased within the past two years, because it has been necessary to give more time and consideration to the requirements of students taking special courses.

The Department has carried out the work prescribed in the catalogue, adhering faithfully to the courses as laid down. Some changes have been made by other departments in the amount of chemistry required in their special courses, adding somewhat to the work of the Department of Chemistry. The amount of our teaching work has, partly due to this fact, increased till we have at this time ten schedule and twenty laboratory hours weekly, which, in the spring and winter terms, will be further increased by ten schedule hours, making twenty schedule and twenty laboratory hours weekly.

The standard of work in the Department has been maintained as heretofore, but we have not been able to advance it as we would be pleased to do. Changes in the course, extending the required amount of work, have not seemed advisable; in fact, they have not seemed permissible under the obtaining conditions. We have, however, tried to keep fairly well abreast with the advances in this subject by the introduction of new text books whenever it has seemed advisable, and we could do so without inconveniencing others.

While I would be greatly pleased to be able to very materially extend the course, both in the class room and laboratory work, I am still of the opinion which I expressed two years ago, i. e., that under the present conditions it would be of very doubtful advisability.

Our facilities for teaching chemistry are good. If our students had the desire and time to prosecute the study of this branch of science, we are in position to offer them excellent opportunities to prepare themselves for advanced work, particularly in those lines pertaining to Analytical Chemistry.

I have no requests to make in connection with the carrying on of the work of the Department.

The building under my charge is in good condition. The only thing, probably, to which I should call your attention is the condition of walls, which, in the course of the nine years that the building has been occupied, have become very black, due, largely, as I believe, to coal dust. The radiators are not provided with any device to divert the current of heated air from the walls or to catch the dust; consequently, the heated air, with its burden of dust and dirt, sweeps against the walls from the radiator to the ceiling, leaving the dust to mark its path. These walls can not be washed. We have tried this with very bad results. The only thing that can be done with them that will probably give continued satisfaction is to paint them, so that they can be washed and in this way be kept clean hereafter.

Respectfully submitted,

WILLIAM P. HEADDEN,
Professor of Chemistry and Geology.

Fort Collins, Colorado, November 8, 1906.

REPORT OF THE DEPARTMENT OF DOMESTIC SCIENCE.

To The State Board of Agriculture.

Gentlemen—The following is the report of the Department of Domestic Science for the fiscal year just closed. As far as was possible, the work has been prosecuted in accordance with the outline scheduled in the catalogue. An intenser interest has been manifested in the Department as a whole than ever before.

We regret that more young women do not take the regular four years' course; however, the young women who are enrolled in the College in any of its departments take an unusual interest in the work. Excellent work has been done by the young women the past year. The only woman graduating in the regular course, Miss Edna Garbutt, secured a scholarship in the Department of Literature and History.

When this class were Freshmen the standard of the College was raised one year. This necessitated the taking of another Freshman year by the class. Most of the women dropped out, hence the lack of women in the 1906 class. There were three Normal students who finished the two years' course prescribed for them, and they, with all other women graduates of the College who so wished, secured positions. Eight young women of the Second Year Normal Class are candidates for graduation.

Some work in regard to new buildings for this Department has been done. While there is nothing tangible to present in the way of definite sums of money being available, at the same time considerable encouragement has been received.

The Department has long since outgrown its present quarters. But for the courtesies shown by Dr. W. R. Thomas and Professor Paddock's Department, I do not see how our work could have been carried on successfully.

I am sure that your Honorable body realizes the needs of the Department, and we feel sure that, whenever you can, you will aid us in securing more comfortable and commodious quarters.

I would recommend that Miss Anna M. Tuttle be given a scholarship.

In regard to special expenditures, I think the Purchasing Committee will handle that according to the best interests of the College.

Respectfully submitted,

THEODOSIA G. AMMONS,
Professor of Domestic Science.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF VETERINARY SCIENCE.

To The State Board of Agriculture.

Gentlemen—This department gives instruction to students in the Agricultural, Domestic Science and Short Courses. The classes are all larger this year, the students are a better average, and the quality of work done, so far, is superior in every respect.

PRESENT QUARTERS INADEQUATE.

We have outgrown our present quarters, and it was found necessary to seek room for the Freshman class in another building. This was unfortunate and was attended with much inconvenience, as the models, charts, skeletons, etc., needed in this class were also necessary in our own rooms for the other classes.

The class in Bacteriological Laboratory is larger this term than usual. Our Laboratory consists of a table along one end of our main class room. This limited space, combined with our meagre equipment, made it necessary to divide the class of fifteen into two divisions, they receiving one-half of the work laid down in the curriculum.

In this Department, as much, or possibly more, than any other, does the practical in education especially appeal. It is of small value to farmer boys to merely discuss the structure of the animal body, the dressing of wounds and animal castration. They must get out and not only see these things, but take a hold and do with their own hands. Our work in Clinic and Dissection, beginning with the winter term, will find us poorly equipped for this practical work. The dissection room has been practically abandoned, on account of being too small and because of the unsavory odors which reach the library above. To use the stock pavilion would be to practically monopolize it for the term. In order to make complete dissections, the cadavers must be kept over for several days, and would be in the way of other classes. The worst feature of it is not the inconvenience, to student and instructor, but rather the fact that we may not be able to maintain the high standards of work hoped for.

DEMANDS FOR A VETERINARY COURSE.

The meat inspection law, recently enacted by the Federal Government, has caused an unprecedented demand for qualified Veterinarians. Such a course established in this school would no doubt be very popular, and would bring to our College a large number of desirable students. If started, however, it should be on a very high plane. The American Veterinary

Medical Association has fixed a high standard for eligible graduation. The days of the "hoss doctor" are few and his destiny is oblivion.

Every College, if it would approach the ideal of the American Association, must see to it that the terms "Gentleman," "Scientist" and "Veterinarian" are synonyms.

An estimation of the probable expense of starting a Veterinary Course has been placed in the hands of President Aylesworth. While my fondest wish is, and my highest ambition all the time has been, to see such a Course established in this Institution, yet I insist that it would be unwise to start it until it can be launched off on such a pretentious scale as would redound to the credit of the College as a whole. The first essential in this respect would be an appropriate building.

I respectfully request that the salary of Dr. Newsom be raised to an amount more nearly commensurate with his ability and services rendered. His work has been very satisfactory.

The Federal Government is bidding for competent Veterinarians at a salary beginning with twelve hundred dollars per annum. We can scarcely hope to keep a desirable man at a less figure.

Respectfully submitted,

GEORGE H. GLOVER,
Professor of Veterinary Science.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF PHYSICS.

To the State Board of Agriculture.

Gentlemen—I have the honor to report that thet past year has been a very successful one for this Department. The work of some classes was rendered difficult by the lack of sufficient lecture room and laboratory quarters, but the students have responded cheerfully and heartily with the instructors for thoroughness in theoretical knowledge and in laboratory practice.

The term just closing has been severe in its demands on the teaching force of the Department, caused, in part, by the natural growth manifested in the increased number of courses offered, in part by the very large enrollment. The latter made the formation of three laboratory divisions in the Sub-Freshman work imperative and necessitates the meeting of laboratory classes continuously from half past one to six P. M.

All classes are showing good interest and the general spirit of the students is of the best. They respond readily and cheerfully to all reasonable requests for work and show a pride in their results that is very gratifying.

Better instruction in all classes has been made possible by thoroughly overhauling the demonstration and laboratory equipment. Many pieces of sorely needed apparatus have been constructed and a system of prompt repair of breakage, wherever possible, keeps all apparatus at high efficiency. Our equipment is gradually rounding toward a well balanced arrangement, but it is still deficient in some special lines, notably Mechanics and Light.

The improvements made in the late summer for better ventilation are very good, provision has been made for installing a fan that will furnish a positive quantity of fresh air as soon as power is available for driving the motor. This promises to solve our problems in ventilation.

The teaching force of the department is striving earnestly to be able to meet the increasing demands that must necessarily be put upon it by the rapid growth of the College, and, in hearty co-operation with the other departments, is working for the highest standards of character and scholarship.

Respectfully submitted,

CHAS. A. LORY,
Professor of Physics.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF CONSTITUTIONAL HISTORY AND IRRIGATION LAW.

To the State Board of Agriculture.

Gentlemen—The regular work of this Department has proceeded in a most satisfactory manner since the date of my last report. Covering five important lines of study in the Junior and Senior years—Advanced History, the Constitution of the United States, Political Economy, International Law and Irrigation Law—constant study and research are required in order to be able to present to the respective classes the latest and most advanced developments in each one of these topics.

The summer vacation was spent in attending the various Teachers' Normal Institutes held throughout the State, and in presenting to these assemblages of educators the claims of industrial education upon the youth of Colorado. Formal lecturers on historical topics, and informal addresses on industrial, constitutional and other subjects which were being considered by the different Institutes were given. From one to four addresses were made to each of the Institutes. The value of this work, which last summer required 3,700 miles of travel, lies in the fact that it keeps the public school teachers of the State in touch and sympathy with the work of the College.

A few words as to the relation of the general work of the Department to the student body, and of its important bearing on the future of its graduates may not be out of place in this connection. While the special duty of the College is to impart an industrial education, no institution maintained by public funds does its whole duty to its students that fails to give adequate instruction along lines that promote good citizenship and impress the civic responsibilities that will devolve upon them when they arrive at the full stage of manhood and womanhood. More than any other, the industrial classes, for whose special benefit this class of colleges was created, and on whom rests the stability of the republic and the future of free institutions, need a knowledge of the constitution of their country; of the system of government and of laws that have grown up under it; of the relation that the nation has borne and should continue to bear to foreign governments; of the influence that such economic questions as markets, transportation, taxation, public expenditures and tariff regulations have upon their personal prosperity, as well as upon the prosperity of the nation. In no other manner can high ideals of citizenship, and of civic uprightness be impressed upon the youth of the State, and as this duty is well performed, so will this College, and all similar

institutions, become influential factors in promoting the welfare of the Commonwealth, and the future greatness of the Republic.

In the arid region, a knowledge of irrigation institutions, of the laws, customs and usages of the distribution and administration of water, is especially necessary for the Agricultural and Engineering classes. There are errors in the past that remain to be corrected; there are problems rising that must be determined in the future, and as these are adjusted wisely, justly, equitably, so will the Agricultural and Horticultural welfare of Colorado be placed on a more prosperous and substantial basis. Hence the intimate relation of the study of irrigation institutions to the Agricultural and Engineering Departments of the College—wise legislation as to water titles, and an efficient and equitable water administration being absolutely essential to all material growth and prosperity in the arid region.

In conclusion I have to express my knowledgements to the President and to my associates in the Faculty and to the members of the Board for their constant courtesy and assistance.

Very respectfully submitted,

W. R. THOMAS,

Professor of Constitutional History & Irrigation Law.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF LITERATURE AND HISTORY.

To The Honorable Board of Agriculture:

Gentlemen—The Department of Literature and History completes another successful year with this report. Attendance upon classes has been large, and the work characterized by increased earnestness on the part of students.

By permission of our College President, and your Honorable Board, I have spent four months of this year in travel in Europe, leaving my classes for the last month of the Spring term in charge of my sister, Mrs. F. G. Willson, of Urbana, Illinois, who completed most satisfactorily the work of the Department for the year. I return to my place this fall with renewed interest, and with the benefit of the inspiration which the student of History and Literature never fails to find in the Old World.

The lecture course for young women supplied for the last three years by this Department is continued, and our thanks are due to the following friends who have given helpful programs since my last report:

Miss Ruth Paxson, Chicago, "In College, What? After College, What?"

Dr. Frank Bayley, Denver, "The Best Gifts."

Miss Olaf Krarer (A native Esquimau), "Life in the Frozen North."

Mrs. Helen L. Grenfell, Denver, "One Part of a Girl's Life."

C. A. C. Girls. A Symposium.

Dr. Louise Hannum, Greeley, "Some Literary Teachers."

Department of Music and Elocution, C. A. C., Recital.

May I call your attention to the fact that the number of women students who select our four years' College course is constantly decreasing. I believe that as soon as funds will permit, this course would be enriched by the addition of more extended work in Modern Languages, and such general science and culture courses as are particularly desired by young women who seek higher education for well developed womanhood. With the additional attraction offered by our courses in Domestic Science, we ought to furnish the most attractive course for women in the State, but while enrollment of women in the four years' courses of other Colleges has increased remarkably during the last few years, we find that in this course our attendance has steadily decreased until this year only four women students, two juniors and two freshmen, are enrolled in our regular four years course.

I wish to express my appreciation of the assistance supplied to my Department this year through the scholarship plan. Miss Garbutt is giving excellent service, both as instructor and office assistant.

May I also express the satisfaction I take in the increased library facilities. Every improvement in the library is an enlargement of every Department of the College.

With hearty appreciation of many courtesies received during the year from our College President and the Board of Agriculture. I am, Very respectfully yours,

VIRGINIA H. CORBETT,
Professor of Literature and History.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF MATHEMATICS.

To The State Board of Agriculture:

Gentlemen--The work of this Department for the past year has comprised classes as follows:

(1) Winter Term, 1905-06.

One hundred and ninety-nine students enrolled in Differential Calculus, Descriptive Geometry, Plane and Spherical Trigonometry, Plane Geometry, Elementary Algebra and Arithmetic and reciting in ten divisions.

(2) Spring Term, 1906.

One hundred and sixty-seven students enrolled in Integral Calculus, College Algebra, Solid Geometry, Elementary Algebra, and Arithmetic, and reciting in nine divisions.

(3) Fall Term, 1906.

Two hundred and fifty-one students enrolled in Plane Analytics, Descriptive Geometry, College Algebra, Plane Geometry and Elementary Algebra, and reciting in ten divisions.

The full program of the catalogue has been accomplished with a good standard of scholarship. The general attitude of the students is for hard work, while the number of failures is not above the average.

My summer in the University of Chicago gave me an opportunity to compare our schedule and standard of work with many other schools in the country. As a result of this investigation it is my purpose to make a few changes in our course--changes toward a more concrete application of the advanced problems of mathematics to physical and engineering science.

I have to report the harmonious co-operation of my two assistants, and beg to express my appreciation to the President and Board for their continued courtesies.

Respectfully submitted,

S. L. MACDONALD,
Professor of Mathematics.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF RHETORIC AND COMPOSITION.

To The State Board of Agriculture:

Gentlemen—In compliance with your order of November 3, 1906, I hereby submit my report for the year ending November 30, 1906.

GENERAL MENTION.

The work of the Department from November 30, 1905, to September, 1906, I can not report as I did not come to the College until September of this year.

During the first term of the college year 1906-1907, we have been making special effort to get in touch with the work and with the general preparation of the students. We have been somewhat handicapped by large classes. The following schedule gives the number of classes and the number of students in the Department during the present term.

Two (2) Sub-Freshman Classes in Lockwood and Emerson's Elementary Rhetoric. Number of students 82

Two (2) Freshman Classes in Baldwin's College Rhetoric. Number of students 85

One (1) Senior Civil Engineering Class in Creighton's Logic. Number of students 3

In connection with the work of this Department should be mentioned the work in Interpretative Reading, by Miss Baker. The course is for the First Sub-Freshmen only. Half the time given to it is taken from History and half from Rhetoric. For further information concerning this course, see the report by Miss Baker.

FIRST SUB-FRESHMAN CLASS.

The First Sub-Freshman Class is composed of students of very unequal preparation. Some of them have come from good country schools, some have come from poor country schools, while some of them have had a year or more in High School. Consequently the best work can not be done. A considerable part of the time that should be devoted to Rhetoric must be given to Grammar. Either the students should be kept out until they have mastered Grammar, or a course in the study of Grammar should be offered. It is hardly fair to keep the students that are well grounded in Grammar back with those who need another year of work in the subject.

The majority of the class is doing good work. Realizing that the ability to speak clearly and forcibly is almost a necessity, the class has organized a debating society, in which every member will

be on the program once a month. The meetings are held every Friday at 11:15 a. m.

FRESHMAN CLASS.

There are eighty-five students in the class. This number includes the Junior ladies from the Domestic Science Department. The program schedule gave us but one hour for the whole class. The recitation room is too small to accommodate so large a class. About half the number agreed to come to class at 7:30 a. m., so the class was divided. One division recites at seven-thirty and one at eight-fifteen. Although the recitation periods are a little short, fairly good work has been done.

We find that the graduates of good High Schools are better prepared than the students who have come up through the preparatory course here. The students from the High Schools have had much more work in English. The text used in this class is for University rather than College students, and is too difficult. We believe that a simpler text, with more practical work will give better results and increase the efficiency of the Department.

Spelling in all classes is poor. Systematic work needs emphasis. To that end every student is working up a long theme (50 to 125 pages), on a subject of special interest to the student making the investigation. Among the subjects for treatment are the following:

The Development of Irrigation in Colorado.

The Development of Hereford Cattle.

The Summer Tourist.

The Combustion Engine and Commerce.

Reclamation of Worn-out Farms.

Transportation and Commerce.

Four months of systematic work will be put upon these subjects. It is expected that methods of investigation and habits of thought will have been acquired that will be of great value.

It seems that if students work along together in the Freshman Class, whether from the Preparatory Course here, or from good High Schools, there should be more work done in the Sub-Freshman course. The students should have daily work in English during the two Sub-Freshman years.

SENIOR LOGIC.

In Logic we are handicapped by a text meant for the specialist and not for business or professional man, who wants only to reason carefully and well. The class is small but means business. The library facilities for the study of Logic are nil, hence the greater need of a superior text.

RECOMMENDATIONS.

1. We respectfully recommend that provision be made for more English work in the Sub-Freshman classes, because the work given is not adequate.

2. We recommend either that students, who are deficient in Grammar, be not allowed to enter the First Sub-Freshman Class. or that a course in Grammar be offered.

3. Since almost daily written exercises are necessary for the best work in English, and since much better work could be done in this Department, could we offer a course in Grammar, we recommend that an assistant be secured for the Department, the said assistant to take one or more classes and aid in the manuscript work.

These recommendations are urged in the belief that much better work would result, were they granted.

Respectfully submitted,

B. F. COEN,
Professor of English.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE WORK IN READING.

To The State Board of Agriculture.

Gentlemen—The work in Reading was begun the last of September. It is confined to the Sub-Freshmen who are grouped into two divisions of forty-seven and thirty-seven pupils each. These classes have now diminished to thirty-two and forty-three students.

The aim of the work is to teach students to read aloud intelligently from newspapers and magazines, or understandingly from a text book, if called upon by an instructor in recitation.

In each recitation there is some formal work from a standard text—Interpretative Reading—In addition they are given sight reading from the current press, and practice work in original talks of two minutes each. It takes two recitations to call on each member of a class, and this gives the individual only two or three minutes.

Particular emphasis is placed on the use of the unabridged dictionary. Students are required to use the main body of the work, the various appendices and the supplement. Practice words and phrases are assigned, and the student not only writes out such work in recitation, but must hand in note books at stated intervals. In addition to the dictionary, the use of a few standard reference books, which are to be found in most libraries, is taught.

I think that intelligent reading aloud is rare, and that this accomplishment is useful and practical for the secondary student.

All of which is respectfully submitted,

CHARLOTTE A. BAKER,
Instructor in Reading.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF MODERN LANGUAGES.

To the State Board of Agriculture.

Gentlemen—The work in the Modern Languages, including French, German and Spanish, is confined chiefly to the Second Sub-Freshman year, although several students in the higher classes take advantage of the work offered, so that we have, in all, about a hundred in this Department. I am asked, almost every day, why the courses, begun in the Second Sub-Freshman class, are not continued in the college proper. I am certain that we lose students every year, because they cannot get the work in Language which they desire.

I should like to suggest that, in the near future, the scope of this Department be widened and enlarged, that the Language work be carried over into the College course, and that students be given an opportunity to take this work if they so desire. Scientific and Engineering students need this work to enable them to read the technical literature necessary to their advancement and success.

Very respectfully yours,

SARAH I. KETTLE.

Instructor in Modern Languages.

Fort Collins, Colorado, November 12, 1906.

REPORT OF THE WORK IN BOOKKEEPING AND FARM ACCOUNTS.

To The State Board of Agiculture.

Gentlemen—I herewith respectfully submit my report as instructor of Bookkeeping and Farm Accounts.

The class in Bookkeeping is small, owing to the fact that only those students taking a straight course and having the time to devote to this subject are eligible for admission. The present courses of study are so arranged that the student desirous of receiving a knowledge of Accounts finds it, in most cases, impossible to do so. Is not this subject important enough to occupy a place in the curriculum of one or more of our courses? At the present time there are thirteen students in the class, all doing creditable work.

The experience I received with the Short Course students, in Farm Accounts, last year assisted me materially in outlining the work for the class this year. The time being limited for class room work, I was obliged to outline something entirely different to our present system. With "Vye's Farm Accounts" as a text, I have arranged a simple and practical system of accounts, a system adapted for the farmer and stockman and one which requires only the minimum amount of work and at the same time gives the necessary information.

We look for a large attendance at the opening of the Short Course term, December first.

Respectfully submitted,

CHAS. G. DWYRE, JR.,
Instructor in Bookkeeping.

Fort Collins, Colorado, November 13, 1906.

REPORT OF THE LIBRARY DEPARTMENT.

To the State Board of Agriculture.

Gentlemen—The following summary of the annual report concerning the Library is respectfully submitted.

There are a number of items besides the inventory and the statistical matter which would properly come into this report, but the principal part is devoted to an outline of the policy of the library with regard to storage of books and library service.

STORAGE, OR SHELVING AND HOUSING OF BOOKS.

Within five years we have grown in bulk from about 10,000 volumes to about 30,000 volumes, and have moved from the old library rooms into the building lately known as the Commercial Building.

We have added shelving until we have about 4,500 feet, and within five years we shall need more than 7,000 feet. We can add nearly 1,200 feet by building another story to the main stack and 324 feet in the reading room.

Either an addition or box storage will be needed at the end of two years (September, 1908). The expense can be kept below $1,000 for an addition just west of the delivery room and between the two wings.

We have about 6,000 volumes shelved in department libraries in the buildings on the College grounds and that can be increased to 10,000 volumes by building additional shelving, but that does not alter the estimates as given above; that will have to be done in any event, if we continue our present department library policy.

The present library building and present accommodations will shelve about 25,000 volumes only and we have about that number on the shelves.

Documents of the United States government must be shelved or we shall lose our designation. There is an agreement equal to a contract to that effect, and we are observing it to the letter and we could hardly give good service in this library without them.

It is frequently remarked by those who use the library and by our visitors that we need a "new library." We do need a new building, but we need a good book collection first. The *service* which is demanded more and more, year by year, calls for a better collection of literature, maps and reference material than we possess, and this report omits all minor questions in order to give space to the points to be considered in *service*.

SERVICE IN THE LIBRARY OF AN AGRICULTURAL COLLEGE.

An *intensive* collection of books is one which is devoted to a definite field with complete, or nearly complete, material in that field of knowledge. It breeds specialists within the library staff and reinforces all the work of faculty and students, whereas a *general* collection scatters its energy, costs too much money without adequate effect and returns, and duplicates the mediocrity of several neighboring collections.

Nearly all the libraries of Colorado and the West are general collections, and we can easily make this library a *notable* collection by *intensifying*.. It will cost money; as much money as a general collection, but the results are not in the same class. A few libraries in America have caught this idea and are easily leaders for reference work in this classes.

It is cheaper for a scholar to take a journey to the John Crerar library in Chicago for scientific work than to stay at home surrounded by all sorts of general and public libraries; Newberry Library for genealogy; Madison or Topeka for history, etc., etc. (East of Chicago the tale is more complete.)

Our present tendency is toward—

Agriculture.
Engineering (our special field).
Domestic Science.
Public Health.

AGRICULTURE.

The importance of immediate work upon our collection is greater than can be explained without an investigation by an active library committee working through a year with regular meetings. Our collection of documents alone is so weak that we should complete what we can before the material vanishes into the maw of an ever-increasing number of new libraries and libraries who have come to this intensive-collection *policy*.

We have bought about everything in United States Agricultural Department publications for sale in the market, and have some money left which we can not spend by correspondence. Our set is still incomplete and we ought to go out and find where the material is stowed away in duplicate collections, in private collection, and for sale in the market. A personal canvass is all that is left for us, and that must be done before another year if we intend to have a good working set of those very important publications. The same is true of state publications and all other official documents in agriculture.

We have catalogues of about 50,000 printed cards to cover the United States Agricultural Department publications, and it is growing very rapidly.

We can still buy books by correspondence.

ENGINEERING.

Periodicals, transactions of learned and engineering societies, official publications and a mass of monograph literature can be bought by correspondence, but a great deal of that is disappearing and some special effort should be made to assist Professors Lawrence, Carpenter and Bainer in filling lists which their ability would make extremely valuable to this library.

DOMESTIC SCIENCE AND PUBLIC HEALTH.

Official documents, monographs, transactions and occasional publications of great value in scientific and popular research lie all about, and we have a great deal to do before we reach the condition which I have described under the head of Agriculture. We can buy from lists and catalogues for a long time and we can increase our correspondence on all these lines.

GENERAL LITERATURE AND CURRENT INTERESTS.

While we are very well equipped for the work under this head we lack a few books of reference value—dictionaries, concordances, glossaries, lexicons, bibliographies—books which skim the cream and condense information for quick use.

LIBRARY COMMITTEE.

There are two library committees; one of the Board and one of the Faculty, and the relation of these two to the librarian, to library policy, and to each other, has never been clear.

In order to shape a policy for this library there should be a *Library Committee with the Librarian as a member* of that Committee. The Committee should meet several times each year and should become familiar with the whole working of this library. My relations with the Faculty Committee of the Library leads me to think that such a committee would be very helpful. The Faculty are interested in this library and always help whenever there seems to be an occasion, but a committee who would make a business of this library policy for a few years would be of great importance in the future of this library.

To the present incumbent it seems important that the librarian should be a member of the Committee on library.

CATALOGUING.

Our catalogue makes progress more rapidly since we have begun to buy Library of Congress printed cards and, in all, we have about 80,000 cards in catalogue condition, ready for use. 50,000 we received as gift for United States Department of Agriculture publications, and 30,000 are in the new dictionary catalogue. The dictionary catalogue will be increased to about 100,000 as fast as we can arrange them.

This form of service is important, and when combined with the help of intelligent specialists will be worth much more than

the cost. It is now in constant use, although incomplete, and it will soon be the most important help in the library.

A thorough explanation of catalogue service and the preparation of the catalogue is not possible in a report, but a great deal is well understood by every one who has to use a library.

INCREASED USE OF THE LIBRARY.

In spite of the fact that we have large Department Libraries and in the face of our circulation records, which do not appear to change from year to year, we are doing an immense amount of reference work for so small a library in such inadequate floor space and with so few helpers. This little library fairly boils with business during the busy hours of the day, and it is the most gratifying thing to a librarian to see the increase of systematic work and intelligent use of books in the student body. Since the improvements in shelving and lighting in the reading room, there is a growing demand for evening service, and as soon as we can see our way clear to do so, the librarian recommends that the library be open for evening use.

APPRENTICE CLASS IN LIBRARY SCIENCE AND ECONOMY.

We are often asked if we have a training class or a library course, and a brief explanation is given here.

We always have two or three students in library training. We require two years' work and not less than four hours a day. We require in addition to our work a reading knowledge in French, or German, or Spanish. Without this one must take regular College work in one Modern Language. No grade below the College entrance requirements will be considered and higher grades are preferred.

We do not guarantee positions to those who take the work, but we have been fortunate enough to place those who complete the work. We are obliged to limit the number of apprentices and we shall have to omit most of the work in binding until we have more room.

Additional reading, either in College classes or under the librarian is required. Examinations are held as in other work.

HISTORY OF THE LIBRARY.

Information concerning the foundation and history of the library may be found in the annual catalogues of the College. The growth and other statistical matter is given in this and previous annual reports of the librarian.

DONATIONS AND EXCHANGES.

The list of donations is too long for this report, covering several pages.

Our exchanges are extremely valuable and run to a large number of pieces. Our list of addresses for mailing to these exchanges is about 300 in number.

BOOKS IN THE LIBRARY—ANNUAL TABULAR STATEMENT.

Latest accession number		14,300
Missing and withdrawn	1,200	
Experiment station library	1,233	
Blank numbers	777	
		3,200
Number of volumes accessioned in the library		11,100
Number of volumes not accessioned in the library		10,100
Bound volumes in College library		21,200
Pamphlets, duplicates and other unbound matter		18,000
Total of all pieces		39,200

Respectfully submitted,

JOSEPH F. DANIELS,
Librarian.

Fort Collins, Colorado,
November 15, 1906.

REPORT OF THE DEPARTMENT OF PHYSICAL TRAINING.

To the State Board of Agriculture.

Gentlemen—I accepted the position of Physical Director of the Colorado Agricultural College in the latter part of July, 1906. I reported in Fort Collins August 25, 1906, and immediately began active work in the way of becoming acquainted with the general surroundings and planning an outline for my year's work.

I am devoting from seven to eight hours daily to the gymnasium, which is entrusted to my care, and it has been my aim to get the best possible results for the College as well as causing the students to feel satisfied with their work.

During the Fall term I had charge of the football team, and while the work was not entirely satisfactory to me, the season ended without injury to any student thus engaged.

The gymnasium classes, while yet in their inception, show increased improvement in general work. The gymnasium is very well equipped for this class work, and the interest shown by the students pleases me greatly. Owing to this fact it will be a pleasure for me to try to cause each one so interested to be in better physical condition by the end of the year.

The different athletic teams are in my charge and I shall devote such time as is beneficial to the College in general to such sport.

Should any member of the Board or Faculty wish to advise with me in the matter of suggestions for the improvement of this branch of College work, I shall be pleased to have an interview at any time.

Respectfully submitted,

C. J. ROTHGEB,
Physical Director.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE WORK IN DRAWING.

To the State Board of Agriculture.

Gentlemen—I am outlining the drawing for the first Sub-Freshman class this term. I have endeavored to carry it along the lines which will be most helpful to the students later in their class and laboratory work, where some drawing is required.

I have confined the work entirely to pencil drawing. The classes may take up some water color or other medium in the spring term. The work this term has been outline, and light and shade in plant forms, blocks, outdoor sketching on the campus, and some figure sketching. Special attention has been given to the study of the rules and laws of perspective.

There have been seventy enrolled in the two classes together, and the work on a whole has been very satisfactory, much more so, in fact, than I had anticipated.

Yours respectfully,

NELLIE M. KILLGORE,
Instructor in Drawing.

Fort Collins, Colorado, November 30, 1906.

REPORT OF THE DEPARTMENT OF INSTRUMENTAL MUSIC.

To the State Board of Agriculture.

Gentlemen—I commenced work as Head of the Instrumental and Theoretical Department of Music at the Colorado Agricultural College, September, 1906, under a contract by which there shall be no expense to the College. During the first term, I have enrolled sixteen pupils in all; three in Harmony, two in History of Music, and sixteen in Piano. At present I am giving twenty hour lessons a week.

There has been great interest shown by the students in their work, and a continued increase in numbers, which is most hopeful.

Respectfully,

ANNE PARKER MINER,

Instructor in Instrumental and Theoretical Music.

Fort Collins, Colorado, November 30, 1906.

REPORT OF THE DEPARTMENT OF VOCAL MUSIC.

To The State Board of Agriculture:

Gentlemen—Since last September I have had charge of the Vocal Department of the C. A. C., also Band, Orchestra, and Glee Club.

I have a good sized class of vocal students, and more to come in the first of next term. There are twelve voices in the Glee Club, all interested, and in a short time will be in good shape for concert work. The Band consists of twenty pieces and is doing good work. The Orchestra will begin work soon.

Respectfully submitted,

R. C. BEAVER,
Instructor in Vocal Music.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF MILITARY SCIENCE.

To The State Board of Agriculture:

Gentlemen—Pursuant to your communication of the 3d instant, I have the honor to render a report covering the period from my joining this Institution to the present.

The undersigned was placed on College duty by Paragraph 10, Special Order No. 39, War Department, dated Washington, D. C., February 14, 1906; joined and assumed command of the Cadet Battalion, and charge of the Department of Military Science and Tactics, March 7, 1906.

The Battalion at that time consisted of a band of 24 musicians and four companies, averaging thirty-eight to the organization, under the command of Major R. A. Maxfield.

The present Battalion is as follows:

Field staff and band	25
Company "A"	56
Company "B"	54
Company "C"	54
Company "D"	54
Total	243

During my first inspection of the Battalion I noticed that the uniform was the same as that recently discarded by the Regular Army, and entirely unfit, as well as unbecoming, in every respect. Report to this effect was made to the President of the College, who informed me that such change as I deemed fit to make in this line would meet with his hearty approval; so, as a consequence, a neater and more appropriate blouse was adopted, which has already brought about a great change in the Cadets' appearance, as well as a pride in wearing it. Formerly, and with reason, the blouses of the Cadets were always worn unbuttoned while out of ranks and on the streets, which must have given outsiders a bad impression of the discipline of the College, but now, I am happy to state, this has been overcome and brought about by the recent change in the uniform, which is much more attractive than formerly, their pride having been aroused in a most gratifying manner.

A service chevron has been added lately. Those that have spent three full years in this College, or other like Institutions, are permitted to wear them. This, also, I have reason to believe, will show good results. The band will make a good appearance with its new white belts and breast cords of mixed red and white, to be worn during parades and occasions of ceremony.

The discipline of the College, as I made report to the Military Secretary, U. S. Army, Washington, D. C., last September, is very good. This, considering the fact that the Cadets are only under the immediate command of the instructor about four hours a week, and the rest of the time either in class rooms or quartered out in town, there being no dormitories.

The need of a drill hall is very apparent, for during inclement weather but two companies can drill at a time in the present armory, which is very poorly ventilated and unfit to be used, outside of a place to store rifles and equipment.

I can not renew the recommendation of the former commandant to change the present light Cadet Springfield rifle for the Krag Jorginson rifle, which, I am informed by the Chief of Ordnance, U. S. Army, has not been lightened for Cadet organization. A rifle any heavier than the present one could not be well handled by certain of the Cadets not up to the physical standard of the others in the companies.

It is to be regretted that no target range is within easy reach of the College, but since so small an allowance of ammunition is allotted, I do not believe good results could be obtained; it takes weeks of very careful training in pointing, sighting and aiming drill before one is qualified to go to the target range. In the meantime the drilling of the companies and battalion is close and extended order ceases.

Lectures and instruction are to be given the Cadets in the following Military subjects: Field service regulations, Army regulations, Hygiene, First aid to the wounded, Firing regulations, and Guard Duty. This is outside of the weekly three-hour practical instruction.

A system of marking should be adopted by the Faculty whereby the Military Professor can tighten up the strings of discipline where needed; standing in the Military Department should count equally with other departments, and those not qualifying themselves should be expelled from the Institution no matter what their standing be.

The Company drill has greatly improved in the last few months.

The interest taken in the Military Department by the President of the College is most gratifying, and I wish also to record my appreciation of the courtesy and prompt support given me as Commandment.

Respectfully submitted,

THOMAS M. ANDERSON, JR.,
Captain 7th U. S. Infantry,
Professor Military Science and Tactics,
Commanding Battalion.

Fort Collins, Colo., November 15, 1906.

APPENDIX

AUDIT OF

State Agricultural College

FROM

DECEMBER 1, 1892, TO NOVEMBER 30, 1903

By Harry E. Mulnix

FROM

DECEMBER 1, 1903, TO NOVEMBER 30, 1906

By Continental Trust Company,

By E. F. Arthur, Auditor.

To the Honorable State Board of Agriculture.

Gentlemen—I have the honor herewith to hand you my report of the business transactions of the Agricultural College and Experiment Station for the period commencing December 1, 1892, and ending November 30, 1903.

I am pleased to say that I find the accounts as kept by your Secretary, Mr. A. M. Hawley, to be in most excellent shape. I believe, however, that his work, which in my opinion is heavier than it should be, can be lessened, if the funds which can be legally drawn from the State Treasurer in a "lump" sum, and paid out locally, are handled in this manner. At present, with the exception of a very few bills, his office is required to make out both vouchers and bills in duplicate. This system, while it is necessary in the present manner of disbursing the college funds, could be safely changed if the accounts were paid at the College in cash, in which case but one voucher and one bill would be necessary. Then, too, in the matter of salaries and student labor accounts, permit me to offer the suggestion that the Secretary make up a pay roll in books prepared for the purpose, and instead of the person being compelled to receipt two vouchers and two bills he would only be required to sign the book when paid. This, I believe, would be a sufficient record for the Institution and would reduce the work of the Executive Committee, the Secretary, and all others who have to handle the accounts of the Agricultural College.

I might add that the disbursements of the Agricultural College funds require more work in the Auditor of State and the State Treasurer's Offices than do all the other state educational institutions combined.

I have made some suggestions to Secretary Hawley with reference to the accounts which my familiarity with the offices of the Auditor and the Treasurer of State leads me to believe that if followed may be of much benefit.

Respectfully submitted,

H. E. MULNIX,
Examiner.

Fort Collins, Colorado, June 1, 1904.

RECEIPTS AND DISBURSEMENTS.

Experiment Station Fund.

Local Treasurer.

RECEIPTS.

1893—December 1 to June 30	$ 8,713.73	
1893-4	19,675.26	
1894-5	17,287.55	
1895-6	15,000.00	
1896-7	15,065.86	
1897-8	15,000.00	
1898-9	15,000.00	
1899-00	15,000.00	
1900-01	15,000.00	
1901-2	15,000.00	
1902-3	15,000.00	
1903—November 30	7,500.00	
		$173,242.40

DISBURSEMENTS.

Overdraft, November 30, 1892	$ 462.82	
Printing Annual Report	1,046.44	
Salary Account	104,661.27	
Stationery, etc.	497.28	
Printing Bulletins	10,886.08	
Building Account	1,697.25	
Meteorology and Irrigation	5,537.97	
Library	171.08	
Divide Station	1,881.94	
Cheyenne Station	6,582.76	
San Luis Valley Station	3,878.63	
San Luis Valley Station Survey	431.67	
Seepage Survey	856.03	
Contingent Expense	30.00	
Feeding Experiment	3,392.62	
Director's Office	2,239.05	
Chemical Section	3,708.18	
Entomological Section	1,947.52	
Arkansas Valley Station	17,110.80	
Executive Committee	409.85	
Association of Agricultural Colleges	70.00	
Agricultural Section	2,002.43	
Horticultural Section	2,062.21	
Traveling	27.50	
Unexpended balance, November 30, 1903	1,651.02	
		$173,242.40

EXPERIMENT STATION.

Special Fund.

Local Treasurer.

RECEIPTS.

1897 and 1898	$ 1,909.11	
1898 and 1899	2,649.40	
1899 and 1900	1,364.78	
1900 and 1901	1,711.85	
1901 and 1902	2,727.69	
1902 and 1903	623.20	
		$ 10,986.03

DISBURSEMENTS.

Agricultural Section	$ 163.81	
Arkansas Valley Station	2,195.65	
Printing Bulletins	1,240.45	
Chemical Section	447.25	
Entomological Section	278.09	
Feeding Experiment	358.65	
Horticultural Section	410.62	
Meteorology and Irrigation	911.56	
Rainbelt Station	741.75	
Salary Account	2,153.29	
San Luis Valley Station	382.70	
Executive Committee Expense	444.35	
Divide Station	21.80	
Stationery Account	110.50	
Director's Office	1,085.57	
Library Account	39.99	
		$ 10,986.03

EXPERIMENT STATION.

Special Fund.

State Treasurer.

RECEIPTS.

1895.		
July	$ 262.62	
September	201.88	
October	159.48	
November	243.85	
December	10.00	
1896.		
March	187.40	
April	835.25	
May	773.10	
June	278.57	
September	60.41	
November	149.96	
December	47.00	
February	162.13	
March	65.60	
		$ 3,437.81

DISBURSEMENTS.

Executive Committee	$ 454.40	
Traveling Expense	24.15	
Arkansas Valley Station	474.56	
Feeding Experiment	123.00	
Salary Account	1,468.28	
Printing Bulletins	555.27	
Printing Annual Reports	100.00	
San Luis Valley Station	75.00	
Chemical Section	30.60	
Irrigation Section	98.50	
Horticultural Section	5.25	
Rainbelt Station	28.80	
		$ 3,437.81

SUMMARY EXPERIMENT STATION AND EXPERIMENT STATION SPECIAL ACCOUNTS.

November 30, 1892, to November 30, 1903.

RECEIPTS.

Experiment Station (Local Treasurer)	$173,242.40	
Experiment Station (State Treasurer)	3,437.81	
Special Fund (Local Treasurer)	10,986.03	
		$187,666.24

DISBURSEMENTS.

Overdraft, November 30, 1892	$ 482.82	
Printing Annual Report	1,146.44	
Salary Account	108,282.84	
Stationery, etc.	607.78	
Printing Bulletins	12,681.80	
Building Account	1,697.25	
Meteorology and Irrigation	6,449.53	
Library	211.07	
Divide Station	1,932.54	
Cheyenne Station	7,324.51	
San Luis Valley Station	3,953.63	
San Luis Valley Survey	431.67	
Seepage Survey	856.03	
Contingent Expense	30.00	
Feeding Experiment	3,874.27	
Director's Office	3,324.62	
Chemical Section	4,186.03	
Entomological Section	2,225.61	
Arkansas Valley Station	19,781.01	
Executive Committee	1,308.60	
Association of Agricultural Colleges	70.00	
Agricultural Section	2,166.24	
Horticultural Section	2,478.08	
Traveling Expense	51.65	
San Luis Valley Station	382.70	
Irrigation Section	98.50	
Unexpended balance, November 30, 1903	1,651.02	
		$187,666.24

AGRICULTURAL COLLEGE AND MECHANIC ARTS' FUND.

RECEIPTS.

Balance in Treasury November 30, 1892	$ 8,209.44	
1893 and 1894	19,000.00	
1894 and 1895	20,203.00	
1895 and 1896	21,000.00	
1896 and 1897	22,000.00	
1897 and 1898	23,000.00	
1898 and 1899	24,000.00	
1899 and 1900	25,000.00	
1900 and 1901	25,000.00	
1901 and 1902	25,000.00	
1902 and 1903	25,000.00	
1903 and 1904	25,000.00	
		$262,412.44

DISBURSEMENTS.

Salary Account	$244,174.46	
Mechanical Department	2,641.14	
Horticultural Department	657.88	
Chemical Department	4,565.78	
Physics and Engineering	1,800.24	
Mathematical Department	32.60	
Zoology and Entomology	619.98	
Library	22.57	
Farm Department	95.40	
History and Literature	93.50	
Unexpended balance, November 30, 1903	7,708.89	
		$262.412.44

RECEIPTS AND DISBURSEMENTS OF AGRICULTURAL COLLEGE TAX FUND.

RECEIPTS

Balance in Treasury November 30, 1892	$ 11.61	
1893 and 1894	34,830.03	
1894	35,352.24	
1895	33,299.51	
1896	31,711.63	
1897	38,072.61	
1898	38,786.56	
1899	36,616.02	
1900	38,504.97	
1901	41,010.48	
1902	60,795.37	
1903	72,858.92	
Overdraft	900.23	
		$462,750.18

DISBURSEMENTS.

Overdraft, November 30, 1892	$ 4,378.80	
1893	26,687.67	
1894	34,876.59	
1895	38,098.16	
1896	32,600.67	
1897	33,777.25	
1898	40,907.68	
1899	32,201.65	
1900	32,945.99	
1901	51,066.38	
1902	59,592.89	
1903	75,410.21	
Transfers and refunds	206.24	
		$462,750.18

RECEIPTS AND DISBURSEMENTS OF THE LAND INCOME FUND.

RECEIPTS.

Balance in Treasury December 1, 1892	$ 5,282.81	
1893-94	9,561.09	
1895-96	9,313.04	
1897-98	13,890.14	
1899-00	16,624.03	
1901-02	20,256.26	
1903	8,369.57	
		$ 83,296.94

DISBURSEMENTS.

1893	$ 10,305.38	
1894	4,286.63	
1895	3,186.16	
1896	5,416.63	
1897	5,893.98	
1898	8,853.83	
1899	.....	
1900	10,913.09	
1901	10,851.76	
1902	13,124.26	
1903	9,968.12	
Reimbursement	361.56	
Balance, December 1, 1903	135.54	
		$ 83,296.94

RECEIPTS AND DISBURSEMENTS OF SPECIAL FUND.

RECEIPTS.

Balance in Treasury December 1, 1892	$ 269.21	
1893-94	5,910.38	
1895-96	5,389.24	
1897-98	3,782.51	
1899-00	5,322.26	
1901-02	11,672.73	
1903	15,141.86	
		$ 47,488.19

DISBURSEMENTS.

1893	$ 1,377.75	
1894	4,417.44	
1895	3,462.15	
1896	1,957.85	
1897	3,786.18	
1898	146.09	
1899	5,245.21	
1901	5,779.80	
1902	5,941.73	
1903	15,175.82	
Transfers	161.65	
Balance December 1, 1903	36.52	
		$ 47,488.19

RECEIPTS AND DISBURSEMENTS OF THE ANNIE JONES LIBRARY FUND.

RECEIPTS.

1895-96	$ 2,836.05	
1897-98	45.00	
1899-00	158.90	
1901-02	854.07	
1903	204.45	
		$ 4,098.47

DISBURSEMENTS.

1896	$ 2,692.90	
1897	147.35	
1898	31.00	
1899	18.00	
1900	18.00	
1901	40.72	
1902	343.75	
1903	200.95	
Balance	605.80	
		$ 4,098.47

STATEMENT OF DISBURSEMENTS OF SPECIAL APPROPRIATIONS MADE BY THE COLORADO GENERAL ASSEMBLY.

1893	By the Ninth General Assembly	$ 6,500.00	
1895	By the Tenth General Assembly	10,000.00	
1901	By the Thirteenth General Assembly	8,000.00	
			$ 24,500.00

DISBURSEMENTS.

1893.

July	Sewer Account	$ 1,248.27	
Aug.	Sewer Account	1,416.60	
Sept.	Sewer Account	2,900.53	
Oct.	Sewer Account	934.60	
			$ 6,500.00

1896.

Dec.	General Improvement Account	$ 100.00	
Jan.	General Improvement Account	4.40	
Feb.	General Improvement Account	461.72	
Mar.	General Improvement Account	581.80	
Apr.	General Improvement Account	458.98	
May	General Improvement Account	1,203.20	
June	General Improvement Account	642.70	
July	General Improvement Account	1,327.75	
Aug.	General Improvement Account	872.48	
Sept.	General Improvement Account	2,377.73	
Oct.	General Improvement Account	1,249.25	
Nov.	General Improvement Account	718.99	

1897.

Sept.	General Improvement Account	1.00	
			$ 10,000.00

1902.

Apr.	Student Labor Account (special)	$ 2,000.00	
Aug.	Improvement Account (special)	2,387.32	
Sept.	Improvement Account (special)	1,740.40	
Oct.	Improvement Account (special)	529.87	
Nov.	Improvement Account (special)	1,342.41	
			$ 8,000.00
			$ 24,500.00

STATEMENT SHOWING THE RECEIPTS AND FOR WHAT DEPARTMENTS AND ACCOUNTS THE REVENUES OF THE TAX, INCOME, SPECIAL, ANNIE JONES LIBRARY AND SPECIAL APPROPRIATION FUNDS WERE DISBURSED, AND THE AMOUNT CHARGED TO EACH.

RECEIPTS

Tax Fund	$461,849.95	
Special Appropriation	24,500.00	
Special Fund	47,488.19	
Land Income Fund	83,296.94	
Annie Jones Library	4,098.47	
Overdraft	122.37	
		$621,355.92

DISBURSEMENTS

Overdraft, November 30, 1892	$ 4,378.80	
Electrical Engineering	447.64	
Constitution and History	15.69	
Seed Distribution	45.70	
Zoology and Entomology	3,963.89	
Domestic Economy	3,224.76	
Commercial Department	4,053.72	
Library Account	7,802.70	
Horticultural Department	21,851.21	
Farm Department	50,539.81	
History and Literature	286.37	
President's Office	3,646.14	
Student Labor Account	22,796.66	
Building Account	225.00	
Fair Exhibit	251.19	
Insurance	9,517.94	
State Board of Agriculture	26,754.23	
Dairy Account	882.41	
Chemical Department	6,112.70	
English and Stenography	461.34	
Mechanical Department	21,740.29	
Mathematical Department	591.82	
Furniture Account	4,835.43	

DISBURSEMENTS—Continued

Physics and Engineering	7,925.88
Remodeling Dormitory	2,075.51
Current Expense	39,898.34
Light and Fuel	18,629.18
Veterinary Science	1,358.11
Text-Book Account	25,261.66
General Repairs	14,313.21
Salaries	132,546.56
Secretary's Office	2,280.45
Military Department	1,040.19
Improvement on Grounds	378.27
Permanent Improvements	71,984.31
Advertising	8,670.98
Hose House	3.84
Agricultural Hall	945.00
Farm House	670.35
Mechanic Shop	182.75
Farmers' Institutes	1,668.12
Annie Jones Library Special	533.95
Freight and Express	8,007.16
Annual Catalogue	4,377.85
Membership A. A. A. C.	70.00
Farm Siphon	5.00
World's Fair Exhibit	857.11
Water Supply	322.25
Sewers	7,118.88
Mechanical Building Heating	1,211.81
Drainage Account	233.10
College Stand Pipes	304.71
Engineering Building	42.00
Mechanical Building Closets	418.91
Irrigation Pipe Line	2,896.22
Extension Water Mains	759.43
Secretary's Report	43.75
Horticultural Building	14,715.41
Compiling Laws	132.00
Reimbursing United States	200.00
Farm Root Cellar	148.00
Flag and Staff	25.00
Course in Agriculture	187.80
Feeding	621.20

DISBURSEMENTS—Continued

Domestic Economy Building Repairs	359.01	
Horticultural Building Furniture	499.75	
Greenhouse	3,106.38	
Plastering	240.92	
Chemical Building	29,250.62	
Plumbing	225.26	
Annie Jones Library	3,492.67	
Advertising Pamphlet	223.45	
Mechanical Engineering Building	4,727.80	
Repairs on Barn	4.50	
Student Labor Special	2,000.00	
Improvement Special	6,000.00	
Refunds and Transfers	729.45	
		$621,355.92

AUDIT STATE AGRICULTURAL COLLEGE.

December 1, 1903, to November 30, 1906.

Hon. P. F. Sharpe, President State Board of Agriculture, Fort Collins, Colorado.

Dear Sir—Pursuant to the instructions of your executive committee, we have made an audit of the books and accounts of the State Agricultural College from December 1, 1903, to November 30, 1906, and herewith submit our findings.

SECRETARY'S CASH.

All collections have been properly accounted for and paid over to the State and local treasurers.

DISBURSEMENTS.

All disbursements are evidenced by duly authenticated bills, and all vouchers are properly approved by the finance committee.

LOCAL TREASURER.

We verified the balances shown as in hands of local treasurer, and find them to be correct.

STATEMENTS.

The following statements exhibit the transactions of the past three years:

SECRETARY'S CASH ACCOUNT.

RECEIPTS.

Balance Library Fund, December 1, 1903	$ 1,056.81
Agricultural Department, sales	8,723.40
Agricultural Station, sales	201.60
Agronomy Department, sales	28.57
Agronomy Section, sales	338.94
Animal Husbandry Department, sales	4,805.64
Appropriation Fund transfers	3,328.41
Arkansas Valley Sub-station sales	723.13
Animal Investigation	142.00
Commercial Department, sales	30.00
Chemical Department, sales	107.50
Chemical Section, sales	271.75
Civil and Irrigation Engineering Department, sales	270.00
Domestic Science Department, sales	19.25
Directors' Office, sales	893.02
Entomological Department, sales	10.00
Engineering Department, sales	350.00
Entrance Fees	1,502.00
Freight Refunded	445.44
Farm Division sales	32.50
Gymnasium Fund	253.00
Girls' Dormitory	345.61
Horticultural Department, sales	163.50
Horticultural Section, sales	25.74
History and Literature Department, sales	12.60
Insurance Refunded	10.00
Irrigation and Engineering Section, sales	5.00
Library Department, sales	74.95
Library Fund Collections (Annie Jones)	407.80
Mechanical Department, sales	43.83
Miscellaneous, sales	150.95
Music Fees	295.50
Physics Department, sales	9.85
Registration Fees	36.00
San Luis Valley Sub-station, sales	1,672.14
Text Book Department, sales	8,222.17
Western Slope Fruit Investigation	1,125.00
Western Slope Fruit Investigation, Transfer	1,303.11
	$ 37,436.71

DISBURSEMENTS.

Paid State Treasurer, Special Fund, 1904	$ 8,250.03	
Paid State Treasurer, Special Fund, 1905	7,589.37	
Paid State Treasurer, Special Fund, 1906	12,590.03	
Paid State Treasurer, Library Fund	1,464.61	
Paid Local Treasurer, Special Fund, 1904	1,555.34	
Paid Local Treasurer, Special Fund, 1905	231.10	
Paid Local Treasurer, Special Fund, 1906	5,756.23	
		$ 37,436.71

RECEIPTS AND DISBURSEMENTS.

	Balance Dec. 1,	RECEIPTS.			DISBURSEMENTS.			Balance Nov. 30,
	1903.	1904.	1905.	1906.	1904.	1905.	1906.	1906.
Agricultural College, Tax Fund	$ 900.23*	$ 64,036.53	$ 69,067.32	$ 69,755.00	$ 61,429.70	$ 66,812.37	$ 75,711.10	$ 1,994.55*
Agricultural College, Land Income Fund	135.54	6,161.61	31,107.00	18,354.31	8,958.66	27,088.27	19,353.48	358.05
Agricultural College, Library	605.80	1,464.61	.....	.....	895.10	.....	1,175.31	.....
Agricultural College, Special	36.52	8,257.53	7,589.37	12,590.03	8,294.05	6,156.76	10,811.84	3,210.80
Agricultural College, Mechanical Arts (U. S.)	7,708.89	25,000.00	25,000.00	25,000.00	26,016.42	23,275.68	24,562.23	8,854.56
Appropriation, Agricultural Instruction	.....	.....	8,000.00	.....	.....	4,013.23	3,986.77	.....
Appropriation, Farmers' Institutes	.....	.....	8,000.00	.....	.....	897.34	7,102.66	.....
Appropriation, Animal Industry	.....	.....	10,000.00	.....	.....	639.24	9,360.76	.....
Appropriation, Plant Industry	.....	.....	3,000.00	.....	.....	941.71	2,058.29	.....
Appropriation, Root Crops	.....	.....	1,000.00	.....	.....	.....	1,000.00	.....
Experiment Station (Hatch) Fund	1,651.02	15,000.00	15,000.00	15,000.00	14,854.46	15,242.16	16,840.87	286.47*
Experiment Station (Adams) Fund	.....	.....	.....	6,750.00	.....	.....	6,294.74	455.26
Experiment Station, Special Fund	15.50	1,555.34	231.10	5,756.23	834.19	281.70	5,376.44	1,065.84
Totals	$ 9,253.04	$121,475.62	$177,994.79	$153,205.57	$121,282.58	$145,348.46	$183,634.49	$ 11,663.49

*Overdraft.

DISBURSEMENTS, COLLEGE FUNDS.

	1904	1905	1906
Agricultural Department	$ 10,789.00	$ 14,459.10	.....
Agronomy Division	.....	10.80	$ 780.72
Animal Husbandry Division	.....	.....	5,414.25
Farm Division	.....	.....	5,842.15
Farm Mechanics Division	.....	.....	236.58
General Agriculture Division	.....	.....	4,732.20
Advertising	1,490.49	2,149.17	2,039.28
Bulletins, Catalogues and Reports	417.68	881.40	1,114.30
Association American Agricultural Colleges and Experiment Stations	15.00	15.00	15.00
Chemical Department	1,724.16	1,184.94	759.75
Commercial Department	384.85	95.82	16.65
Constitutional History and Irrigation Law Department	20.50	10.45	53.85
Current Expense	2,464.86	2,112.22	804.10
Civil and Irrigation Engineering Department	752.50	1,143.81	2,019.17
Domestic Science Department	430.25	603.37	551.06
English and Sociology Department	16.70	43.87	9.15
Electrical Engineering Department	595.99	1,282.63	.....
Electrical Supplies	.....	407.98	162.90
Furniture	1,513.10	1,734.50	.....
Freight and Express	1,343.96	2,436.29	1,557.01
Fuel and Lights	3,990.44	3,756.04	4,785.86
Farmers' Institute Division	563.55	1,485.94	5,003.19
Firemen and Janitors	.....	.....	3,282.26
General Repairs	2,202.77	3,684.72	2,043.04
Girls' Dormitory	.....	1,272.45	785.41
Horticultural Department	2,872.43	3,780.99	3,465.00
History and Literature Department	47.25	58.47	27.50
Insurance	311.05	1,160.10	993.75
Library	1,856.56	1,761.15	2,695.19
Mechanical Department	2,700.23	4,440.34	2,368.39
Mathematical Department	16.00	13.70	8.60
Military Department	155.14	229.46	74.22
Music Department	.....	.....	118.84
Modern Languages Department	.....	.....	13.45
President's Office	250.83	562.43	1,442.67
Physical Training Department	.....	.....	17.30
Permanent Improvements	9,967.23	12,496.12	14,060.31
Salary	50,191.96	53,775.27	61,807.02
Secretary's Office	255.44	816.20	985.82

DISBURSEMENTS, COLLEGE FUNDS—Continued.

State Board of Agriculture	1,458.85	1,742.55	1,291.40
Student Labor	3,862.19	3,988.69	3,655.80
Text-Book Department	2,632.09	3,111.50	3,305.01
Veterinary Science Department	106.85	137.07	352.30
Zoology and Entomological Department	194.03	1,399.11	222.66
Transfers to other funds	.....	.....	3,790.28
Totals	$105,593.93	$128,243.65	$142,703.39

DISBURSEMENTS, EXPERIMENT STATION FUNDS.

	1904	1905	1906
Agricultural Section	$1,335.48	$ 869.56	$ 56.27
Association American Agricultural Colleges and Experimental Stations	15.00	.....	.....
Arkansas Valley Sub-station	49.36	45.65	54.12
Animal Investigation Section	.....	144.83	2,024.11
Agronomy Section	.....	310.35	2,483.55
Bulletins and Reports	518.20	2,521.98	5,457.19
Buildings	.....	141.40	5,236.68
Chemical Section	366.51	31.75	1,345.47
Director and General	536.56	530.72	1,716.58
Entomological Section	294.71	327.02	1,053.05
Horticultural Section	284.68	390.48	1,570.48
Insurance	.....	6.00	33.00
Library	21.42	59.42	1,912.63
Meteorological and Irrigation Section	893.77	252.26	2,347.39
Plains Sub-station	74.00	.....	.....
Salary	11,292.96	10,681.10	11,136.07
San Luis Valley Sub-station	6.00	.....	.....
Veterinary Section	.....	234.60	951.83
Western Slope Fruit Investigation	.....	.....	2,428.11
Transfers to other funds	.....	557.69	1,121.57
Totals	$15,688.65	$17,104.81	$40,931.10

CERTIFICATE.

We have made an audit of the books of the State Agricultural College from December 1, 1903, to November 30, 1906, inclusive; and in accordance therewith we certify that the foregoing statements correctly represent the transactions for the period named.

THE CONTINENTAL TRUST COMPANY,
E. F. ARTHUR,
Auditor.

(SEAL.)
Dated December 8, 1906.

Note—Mr. Arthur also says, "The system in use for the payment of accounts through the State Treasurer is cumbersome and antiquated. Every invoice is duplicated for attachment to the voucher drawn on the State Auditor. If all funds can be drawn from the State Treasurer in bulk and placed in the hands of the local treasurer, this duplication can be avoided and accounts paid by warrant on the local treasurer, each warrant specifying the fund against which it is drawn."

THE STATE AGRICULTURAL COLLEGE
OF COLORADO

NINETEENTH ANNUAL REPORT

OF

THE AGRICULTURAL EXPERIMENT STATION

FOR

1906

LETTER OF TRANSMITTAL.

To His Excellency,
HENRY A. BUCHTEL,
Governor of Colorado.

In accordance with the requirements of an act of Congress providing for the establishment of agricultural experiment stations, I have the honor to present herewith the report of the Colorado Experiment Station, it being the nineteenth annual report. The report of the activities of the Station is for the whole year, while the fiscal report ends with June 30, in conformity with the fiscal year of the United States.

The report and the accompanying documents give an indication of the activity of the Station. The publication of the experiments is made in separate form, as bulletins, which are widely distributed among the agricultural population of the State.

Respectfully submitted,

L. G. CARPENTER,
Director.

The Agricultural Experiment Station,
State Agricultural College,
Fort Collins, Colorado,
January, 1907.

THE AGRICULTURAL EXPERIMENT STATION,

FORT COLLINS, COLORADO.

THE STATE BOARD OF ARGRICULTURE.

	Term Expires
Hon. P. F. SHARP, *President*, Denver	1907
Hon. HARLAN THOMAS, Denver	1907
Hon. JAMES L. CHATFIELD, Gypsum	1909
Hon. B. U. DYE, Rocky Ford	1909
Hon. B. F. ROCKAFELLOW, Canon City	1911
Hon. EUGENE H. GRUBB, Carbondale	1911
Hon. A. A. EDWARDS, Fort Collins	1913
Hon. R. W. CORWIN, Pueblo	1913
Governor JESSE F. McDONALD, President BARTON O. AYLESWORTH,	*ex-officio.*

EXECUTIVE COMMITTEE IN CHARGE.

P. F. SHARP, Chairman. B. F. ROCKAFELLOW.
A. A. EDWARDS.

STATION STAFF.

L. G. CARPENTER, M. S., *Director*.....Irrigation Engineer
C. P. GILLETTE, M. S.....Entomologist
W. P. HEADDEN, A. M., Ph. D.....Chemist
W. PADDOCK, M. S.....Horticulturist
W. L. CARLYLE, M. S.....Agriculturist
G. H. GLOVER, B. S., D. V. M.....Veterinarian
W. H. OLIN, M. S.....Agronomist
R. E. TRIMBLE, B. S.....Assistant Irrigation Engineer
F. C. ALFORD, M. S.....Assistant Chemist
EARL DOUGLASS, M. S.....Assistant Chemist
A. H. DANIELSON, B. S.*.....Assistant Agriculturist
S. ARTHUR JOHNSON, M. S.....Assistant Entomologist
B. O. LONGYEAR, B. S.....Assistant Horticulturist
J. A. McLEAN, A. B., B. S. A.....Animal Husbandman
E. B. HOUSE, M. S.....Assistant Irrigation Engineer
F. KNORR**.....Assistant Agronomist
P. K. BLINN, B. S..Field Agent, Arkansas Valley, Rocky Ford
E. R. BENNETT, B. S.....Potato Investigations

WESTERN SLOPE FRUIT INVESTIGATIONS, GRAND JUNCTION.

O. B. WHIPPLE, B. S.....Field Horticulturist
E. P. TAYLOR, B. S.....Field Entomologist

OFFICERS.

L. G. CARPENTER, M. S.....Director
A. M. HAWLEY.....Secretary
MARGARET MURRAY .....Clerk

*Resigned December 1, 1905.
**Appointed December 1, 1905.

REPORT OF THE DIRECTOR.

ORIGIN AND ORGANIZATION OF THE STATION.

The Experiment Station of Colorado was organized in February, 1888, in accordance with the Hatch act of Congress, passed in 1887, and made effective in 1888. The organization is under a Director, with the subdivisions of the Station called sections. The idea in this organization was that the Station as a whole had the rank of a department. The Executive Committee has more direct charge of the Experiment Station. The rules relating to organization were adopted by the Board some years since, adopting the suggestion of the Director of Experiment Stations of the U. S. Department of Agriculture. The Board has also recognized that the Experiment Station is the experimental and investigational side of the College, and has provided by resolution that all experimental work shall be considered as a part of the Experiment Station, and, therefore, under its direction. Under the State law experimental work is contemplated as a duty of the State Board of Agriculture, and it seems proper for some of the funds to be used for such purposes if the Board deems it advisable. In that respect our State law is broader than the laws in most states.

The appropriation from the Hatch fund is $15,000 per annum. This fund is surrounded by certain limitations, but is much broader than the provisions relating to the Adams fund. Some supervision rests in the Secretary of Agriculture.

At one time a large part of this fund was diverted to substations. The United States decided that this was not a proper charge on the Hatch fund, and that such use must be discontinued. The older members of the Board will remember the period of several years' effort to withdraw from the substations, and the local influence, without entanglements and without getting into difficulties.

The Adams bill has been passed through the efforts of the Agricultural Colleges and Experiment Stations the past winter. This fund is much more restricted in its provisions. Five thousand dollars was available the first fiscal year, $7,000 the second, and so on, increasing until it reaches the full amount of $15,000. In the case of this fund it can not be used for many purposes for which the Hatch fund is available. It can not be used for printing, for administration, postage nor many of the other necessary functions of the Station. It is available only for original scientific research and experiment. This fund is also more directly under the control of the Secretary of Agriculture.

During the past year some funds have been available from an appropriation by the State. This appropriation has been for special purposes. Also, some revenue has been received from the Fruit Growers of the Western Slope for investigations, which have been supplemented by the Board.

FUNCTION AND OBJECTS OF THE STATION.

The passage of the Adams bill, and the questions and discussions which have arisen from it, have caused a very general consideration of the scope and function of the Experiment Stations. Serious thought has been given not only here, but in all the other Stations in the Union, and has been the subject of discussion at the meeting of the Experiment Stations, at the Society for the Promotion of Agricultural Science and related organizations. Both the Hatch and Adams acts give a different interpretation.

In the eighteen years since the organization of the Experiment Stations under the Hatch act, the Stations have been reaching a clearer understanding of their functions. They have gained a much larger hold on the public mind, and in this very fact lies also a danger to the most important work of the Experiment Stations. With the development of their work there has been a constant tendency for greater demands to be made upon the Stations, often a proper one, especially when the demand is accompanied by funds from the State appropriation to meet the demand. In such cases, the conditions surrounding the work and the duties of the Station may be whatever the State may deem desirable to assign, so far as the State funds will permit. Therefore the lines of work in such states supported by state appropriations can not be taken as a guide for those lines which depend wholly upon United States funds.

The Hatch fund is available for research and experiments and for verification of experiments, and for printing and distributing results.

The Adams fund can be used only "for paying the necessary expenses of conducting original research and experiments." This limitation in the scope of the act was an intentional one on the part of Mr. Adams, and means much in the interpretation of the act. It had been felt that in many cases the Hatch fund had not been used properly, and that the temptation was to use it for doing work that was popular and not scientific, and that work was often undertaken that should more properly be undertaken by the State.

The act was intended by the author to encourage, if not to force, the various states to supplement the fund by appropriations or other funds. The Adams act makes no provisions for heating, lighting, buildings, janitor service, publications, correspondence, stenographers and many other indirect but necessary expenses. A result of the investigations will be an increase in the number of publications, and probably in the number of copies which need to be printed. The work under the Adams fund was

not intended to include the application, but to be the research which would permit the applications to be made at other expenses. Hence, in order to make use of the funds provided by the Adams act, considerable additional money is needed.

The first effect of the Adams act will not be, therefore, to relieve the financial situation of the Station. But as it makes the obligation correspondingly greater, it will be still more difficult to make ends meet in the future unless there can be other support.

There will undoubtedly be disappointment with the first results of the act, because such researches as are contemplated by the act can not reach conclusions short of several years, and, therefore, for the first few years there may be a feeling that the apparent results are not commensurate with the cost. There is however a growing realization of the fact that the best results come from this thorough work. The Department excludes such tests as variety tests, market tests, and tests that do not tend to answer definitely the question "why," or to determine the reasons.

There are so many lines of usefulness for a scientific staff and so many opportunities, that there has been an increasing call for the Stations to do work of a secondary grade, like testing plants, determining the merits of different varieties, testing seed, testing the merits of the different combinations of food, and in short to do many things which do not require any particular scientific knowledge, but only opportunity, and possibly some funds. Some phases of this work are often of extreme economic importance to a community or to the State. The improvement of wheat, the distribution of an improved variety of wheat, the development of an improved variety of potatoes, may be a matter of very great importance. It is the kind of work which naturally clusters around an Experiment Station, and in the past the various states have done a great deal of this kind of work. Such work has been supported mostly, if not entirely, from other funds, but as that fact is not made clear in the publications of the Stations, it gives a wrong idea of what the Stations could do from government funds. Such work is extremely valuable to supplement the more scientific work of the Stations. It is a work whose financial benefit is more immediately seen. It was, therefore, left without aid by Mr. Adams, with the feeling that its financial importance would command support, and this should be from the states, or from other sources.

For these purposes, and for the general purpose of utilizing the Adams fund to the best advantage, some support is needed from the State, and should increase more as the Adams fund becomes larger.

The Legislature two years ago made an appropriation to the State Board of Agriculture for the Experiment Station, and a continuation is needed for the present biennial period. The amount appropriated in 1905 in S. B. No. 172, approved April 6th,

was $14,000 for the biennial period; $10,000 for the lines of animal industry; $3,000 for the lines of plant industry, and $1,000 for potatoes and other root crops.

This appropriation has proven to be of such value, and has been so useful in many parts of the State, that a continuation and extension of the purposes for which these funds were available is needed.

While there is increased recognition of this application of scientific research, it can not be too frequently impressed that these applications can not be made unless the research has previously been made. These applications must depend upon sound research, and it is this work which is the highest function of the Experiment Station, and is the work which is intended to be fostered by the Adams act. Research in the broader sense attempts to answer the question "why." It requires the highest kind of intelligent effort, and should be classed with the highest kind of creative work. The investigator requires peculiar conditions. He should be separated from disturbing influence and from such routine work as saps his energy and vitality and which could be done by cheaper help.

The value of these conditions as provided by Mr. Adams will be increasingly evident as the years go by.

THE FRUIT INVESTIGATIONS.

The fruit growers of the Western Slope made special request for help in the problems which were troubling them, and offered to raise considerable money if the State Board of Agriculture would supply men to aid them, under the direction of the Experiment Station. The Station could not use its funds. Realizing the value of such work, the State Board of Agriculture made special provision, and with the aid furnished by the fruit growers of Mesa county, they carried on investigations on the Western Slope during the past year. The general investigation included two men, one Field Horticulturist and one Field Entomologist, working under the direction of the Horticulturist and Entomologist of the Experiment Station. The investigation was to include the study of the orchard conditions of Mesa county, especially of the injurious insects, the means of combatting them, and the means of improving conditions. Mr. O. B. Whipple, who was Assistant Horticulturalist, was detailed for the work at Grand Junction, under the direction of Prof. Paddock, and Mr. E. P. Taylor, of Illinois, was engaged as Field Entomologist, under the direction of Prof. Gillette. The work was more especially confined to Mesa county, although it was planned on a broad enough scale to take up other counties if time permitted. It was thought best, however, to confine the work to a relatively limited section until it was found that it could be broadened. As a matter of fact, Mesa county alone took the complete energies of the force, and no systematic work was done outside. Some attention was given to Delta and Montrose counties, and enough

so as to keep in touch with the problems of those regions, with the hope of taking up the work there during another year. In addition to the work of the Field Horticulturist and Entomologist, arrangements were made so that investigation of the seepage question was also taken up, and an investigation carried on for a part of the season in conjunction with the other work of the fruit investigation. This was conducted by Mr. F. L. Payne and Prof. House, and directed to find, first, the source of the seepage, where it had been injurious, and then, based on that, to determine the remedy. Some important lessons have been learned which will be fruitful, and will result in a benefit in this way. The total expense of this investigation was estimated to be $5,000 for the calendar year. That amount has not yet been expended, but apparently will be before the end of the fiscal year. If the expense of the seepage investigation is included, the total expense will be over $6,000. For the coming year, with the extension of such work, this would require nearly $10,000.

CO-OPERATIVE WORK WITH THE DEPARTMENT OF AGRICULTURE.

The work of this kind which has attracted the most attention is the horse breeding work, in connection with the Department of Agriculture. For this purpose, the Department of Agriculture provided a horse with an excellent record, and a number of mares also with excellent records. The Department of Agriculture furnished these at a total cost of about $15,000. There were also some gifts.

The provision in the State appropriation for animal industry was rendered available for the construction of a barn, and the total amount put into this barn for this purpose was slightly above $5,000. The college has also furnished pasture ground some three miles west of the Station, and has found it necessary to buy more during the year. There are now a number of excellent colts. The Department of Agriculture contributes $1,000 for the minor expenses of the Experiment. This is to go into equipment, but as the rules for auditing bills are troublesome for the purchase of such materials, the Department contributes this amount as a part of the salary of the Professor of Agriculture, with the understanding that the College will use the corresponding amount toward the minor expenses of the experiment. The Department of Agriculture also pays the salary of a groom, and also meets a number of minor expenses. The work calls, however, for funds from the College.

Under the agreement with the Department of Agriculture, the colts may be sold, except such as may be selected to continue the work. The proceeds from these colts go into the maintenance of the experiment. It is, therefore, hoped that the revenue derived from this source may materially aid in the cost of the experiment.

LOCO INVESTIGATION.

The loco investigation at Hugo has been in co-operation with the United States Department of Agriculture. It is an

outgrowth of previous work done by us with Mr. Payne, when we reached the conclusion that the loco problem needed to be taken hold of on a much more extensive scale. Co-operative arrangements were made with the Department by which we furnished the animals, the services of the Veterinarian, while the Department kept a man and maintained the work. The cost has been principally for the animals. At the end of last winter there were six horses and six cattle, and these were increased by purchase until there were 25 cattle and 25 horses. Of these a number have died during the season, so that at the time the invoice was made, December 1, there were 21 cattle and 13 horses. These are to be put at pasture, and a few have been brought here for better care and to test various remedies and the effect of good feed. The cost has been borne by the special State appropriation. It has amounted as a whole to $1,152.64. The Department of Agriculture feels that they are enabled now to find the cause.

The Experiment Station, through the appropriation of the Legislature, provided a number of cattle and also horses, which were used as the subjects. Careful studies were made by Dr. Marsh. The first and most important step was to attempt to determine conclusively whether the plant was the cause of the loco disease. While there has been a good deal of assertion, and a great many who are convinced either that the plant is or is not, the connection between the disease and the plant had not been so positively determined that it was safe to assume. The test of Dr. Marsh included not only the full tests on the animals, but also a study of the plant, and an attempt to determine a poison in the plant by physiological tests. Dr. Marsh reports that the results of the loco investigation of the past two seasons has substantiated the following things:

"1. In our laboratory in Washington a poison has been definitely separated from the loco plant, and is now being subjected to more complete pharmacological and chemical investigation.

"2. In the field work we have demonstrated definitely the connection of the loco plant with the loco disease, and we have determined to some extent the relative danger of the different kinds of loco plant.

"3. We have also determined definitely the pathological lesions that accompany loco poisoning, so that we can by post-mortem examination make pretty exact diagnoses of the cases.

"4. Considerable work has been done in the way of experimental dosing, but so far without final results.

"5. Considerable attention has been given, and with some success, in investigation methods of exterminating or reducing the number of loco plants.

"It seems to us that the work of the next season must be confined to more detailed investigation under these last two

heads. This, of course, is the practical end of the loco problem, and the solution of the possibilities of dosing, and the possibilities of the destruction of the loco weed would mean the solution of the whole problem."

Under the State appropriation of 1905 for animal industry, of the total appropriation of $10,000, about $5,000 was expended, as mentioned, for stables for the co-operative work with the government. A portion was used in the loco co-operative work, and Prof. Carlyle chose to use the remainder in the expenses in a test to determine the economic conditions of taking range stock and feeding. He has selected a number of calves. One set is brought to the Station at one year old, and fed; a second set remains on the range for two seasons, and a third set for three seasons. Each set is then to be brought to the Station and fed, and finally, when sold, the comparison in the size and gain is to be made.

THE WORK IN PLANT INVESTIGATION.

A considerable co-operative work was taken up by Prof. Olin, and a good deal of energy given to the dissemination of Durum wheat, with a result of a large increase in the crop grown. The work of a number of years in the development of improved wheat and oats in the San Luis valley resulted in the spreading of improved grains, and promises practical results. Very interesting and valuable tests were made with grains and alfalfa.

The fund appropriated for potato and root crop investigations was too small to be of much value in itself, but when aided from other sources, it was possible to employ a potato specialist, Mr. E. R. Bennett, who gave his whole time to the study of the potato industry and the improvement of potatoes. For a part of the season, his headquarters were at Greeley. This has resulted in Bulletin No. 117.

PUBLICATIONS OF THE YEAR.

During the year the Station has issued bulletins from 107 to 116, inclusive, five press bulletins, Nos. 24 to 28, inclusive, and three reports and special bulletin No. 100. The regular bulletins had a total of 192 pages, press bulletins ran from two to four pages each, making a total of 16 pages, and the reports, a total of 478 pages. The edition of the bulletins ran from 3,000 to 10,000. The reason for the publication of three reports was because two reports had not been published at the time they were made because of the stress of funds when the printing fell upon the Station. The total number of pages obtained by multiplying the number of the edition by the number of pages in the bulletin is nearly 5 million pages; leaving out bulletin 100, the total is about 2 million pages.

In this list is bulletin 100, which has been the subject of a note in the annual reports for several years. It is on the Flora

of Colorado. It is a credit to the Station and to the College. While it is a bulletin that will not be sought by the ordinary user, yet it will reach circles that could not be reached by the ordinary bulletins, and will give credit to the Institution and be of value to the State.

BULLETINS ISSUED DURING YEAR 1906.

No.	Pages.	Edition.	Total No. of Pages.
107	8	9,500	76,000
108	18	9,500	171,000
109	12	8,500	102,000
110	16	10,000	160,000
111	12	9,500	114,000
112	8	8,500	68,000
112	32	9,500	304,000
113	46	10,000	460,000
115	24	9,500	228,000
116	16	3,000	48,000
		87,500	1,731,000

PRESS BULLETINS.

No.	Pages.	Edition.	Total No. of Pages.
24	2	3,000	6,000
25	4	3,000	12,000
26	4	8,500	34,000
27	4	9,000	36,000
28	2	3,000	6,000
		26,500	94,000

REPORTS.

No.	Pages.	Edition.	Total No. of Pages.
14 (1901)	54	750	40,500
16 (1903)	40	750	30,000
18 (1905)	65	1,250	80,000
		2,750	150,500

The list is as follows:

No. 100. Flora of Colorado, by Dr. P. A. Rydberg.

No. 102. Feeding Steers on Sugar Beet Pulp, Alfalfa Hay and Ground Corn, by W. L. Carlyle and C. J. Griffith.

No. 103. The Thorough Tillage System for the Plains of Colorado, by W. H. Olin.

No. 104. A Rust-Resisting Cantaloupe, by Philo K. Blinn.

No. 105. A New Apple Rot, by B. O. Longyear.

No. 106. Pruning Fruit Trees. by Wendell Paddock.

No. 107. Peach Mildew, by O. B. Whipple.

No. 108. Development of the Rocky Ford Cantaloupe Industry, by Philo K. Blinn.

No. 109. Cultural Methods for Sugar Beets, by W. H. Olin.

No. 110. Alfalfa, by W. P. Headden.

No. 111. Alfalfa, by W. P. Headden.

No. 112. A Hopperdozer, by P. K. Blinn.

No. 113. Larkspur and Other Poisonous Plants, by Geo. H. Glover.

No. 114. Insects and Insecticides, by C. P. Gillette.

No. 115. Fertilizer Experiments With Sugar Beets, by A. H. Danielson.

No. 116. The Cottony Maple Scale, by S. A. Johnson.

The bulletins are now ordinarily issued in editions of 9,000. In cases, such as seem to be of more than ordinary interest, 10,000 is printed. Technical bulletins may be printed in an edition of 3,000 or less.

INVESTIGATIONS OF THE YEAR.

In most cases, the investigations carried on during the year have been continuations of work previously in progress, or development that has come as a consequence of previous work. The opportunities in the State are so great that there is a constant tendency to make much more extensive plans than can be carried out. The interference, with other duties of the College, of extension work, also prevents the completion of as much work as contemplated, and the same result is caused by the fact that every investigation broadens and extends as the investigation proceeds.

The essential method has been for the lines of investigation to be made by the heads of the different sections and submitted to the Director for co-ordination or suggestion. It has not been the custom for the Director to materially change the plans except as might be necessary to agree with general lines or to fit in with the work of other sections. The Director has, however, exercised the discretion of preventing duplication of work. Under the Adams act in the future it will undoubtedly be necessary for closer control than has been customary in the past.

Outlines of the work of the past year as approved have been as follows:

OUTLINE OF WORK FOR IRRIGATION ENGINEERING SECTION, 1906.

1. Meteorology as hitherto.

The development of lysimeter records, that is, the flow of water through soils.

3. Evaporation through soils under different conditions.

4. The irrigation survey of Colorado. This to include an examination of the State, taking up one valley at a time; a description and map of the canals and study of the methods of irrigation, of the peculiarities of canals as related to local situation and to crops, suggestions as to improvements, and study of such questions as may be found to be desirable for that locality, as, for example, water supply, drainage, storage, etc. This would require several years, but reports and bulletins would be issued as they proceed.

5. The application of water to crops. This has resulted in the past in the studies of the duty of water. Additional equipment of self-recording instruments makes it possible to take this up on a larger scale, and with the variety which is necessary to secure good results. Former co-operative trials have not been entirely satisfactory, but such trials have been necessary from the lack of instruments which now is partially remedied.

6. In connection with the Western Slope fruit investigation, to take up the question of seeped lands in the vicinity of Fruita and Grand Junction. This will require a number of visits, and quite probably a special man for several months.

L. G. CARPENTER.

OUTLINE FOR ENTOMOLOGICAL SECTION, 1906.

1. Collecting and rearing insects to determine food, habits, life histories and Colorado fauna. (Continued work.)

2. A study of sugar beet insects. (Continued work.)

3. Habits and remedies for potato flea beetles. (Continued work.)

4. A study of the habits and remedies for plant lice, with special reference to the woolly louse of the apple.

5. A study of loco insects.

6. A field experiment on the Western Slope to test remedies for the codling moth.

7. *Apiary.*

(a) A continuation of the study to determine relation of bees to apple and pear blight.

(b) Testing different strains of the honey bee.

C. P. GILLETTE.

OUTLINE FOR CHEMICAL SECTION, 1906.

I. Digestion experiments with sheep. (Continued.) Will be finished about midsummer. This is a continuation of studies already reported in bulletins 39 and 93.

II. Study of alkali as occurring in Colorado. (Continued.) This is a study as related to soils and irrigation questions.

III. Methods of extracting beeswax. This work is nearly done, and will be ready to report some time during the year.

IV. Deterioration of barn yard manures. (Continued.) This investigation is to be carried on for several years.

V. Waters of irrigation. This is a continuation of work hitherto begun, especially in the San Luis valley.

VI. Miscellaneous work.

W. P. HEADDEN.

SECTION OF HORTICULTURE AND BOTANY.

OUTLINE OF WORK FOR THE YEAR 1906.

Potato. Testing varieties. Breeding. Diseases.

Plant diseases in general.

A study of horticultural conditions.

Forestry.

FARMERS' FRUIT CO-OPERATIVE ORGANIZATIONS.

To take up the study of the various Farmers' Fruit Co-operative Organizations in the State as instances of organization and co-operation. To study the causes of organization, the methods, expenses and financial results.

To take up these organizations one at a time and make a study of them, and of the Farmers' Co-operative Organizations, of which the cantaloupe organization will be a particular type.

HORTICULTURAL SECTION.

POTATO INVESTIGATIONS: GREELEY.

The principal line of work will be to discover why potatoes run out, and in order to do this one should be with the crop practically the entire season. Irrigate and cultivate if need be, anything to become thoroughly familiar with the growth of the potato plant. This will necessitate a study of all phases of potato cultivation.

Insects and diseases should be studied at the same time.

Selection of seed potatoes from individual hills to be made in the field in the fall.

Data to be collected during the season for a bulletin on potato industry, to be published next winter.

W. PADDOCK.

WESTERN SLOPE HORTICULTURAL INVESTIGATIONS.

OUTLINE OF WORK FOR THE HORTICULTURIST.

Every orchard in Mesa county must be visited as soon as possible and inspected, particular attention being given to spraying pear blight, crown gall, wolly aphis, and all orchard pests; cultivation, pruning, irrigation, and, in fact, all horticultural operations. An orchard survey will be conducted at the same time.

Thus far Mesa county has been almost free from pear blight, but unless all signs fail it will do great damage there next sea-

son, unless means are taken to prevent. There should be a strong effort made to induce all orchardists to destroy all traces of blight before spring opens.

Special: Experiments to control the new apple and pear rot, *Alternaria*.

W. PADDOCK.

TREE PLANTING EXPERIMENT WITH CATALAPA SPECIOSA AND BLACK LOCUST.

Purposes. To determine the adaptability of these two species, as utility trees, to the different localities in this State, and to obtain data for guidance of tree planters.

To encourage and educate the public in the matter of tree planting for posts, poles and fuel, by means of demonstration plantations.

Trees Selected. The trees selected are the hardy or western catalpa (Catalpa speciosa) and the Black Locust (Robinia pseudacacia). They were chosen because of their general utility qualities, viz.: ease of establishing, hardness, rapid growth, great durability when in contact with the soil and good full value.

Plan of the Experiment. (a) A plantation of 300 trees of each species to be established in each of twenty representative localities in the State.

(b) Each plantation to be put in charge of some responsible person who shall volunteer to furnish the ground, set the trees and irrigate and cultivate them according to instructions.

(c) The Experiment Station to furnish the trees free of expense to the person in charge, to supervise the planting of the trees, and to leave the plantation entirely in the possession of the owner of the ground at the end of ten years.

Details of the Plantation. The trees of both species to be planted in rows six feet apart, with the trees four feet apart in the row, thus covering about one-third of an acre. The rows to extend usually north and south, and the area covered to be not more than twice as long as broad; a wind break to be used where thought necessary.

PROPOSED LINES OF INVESTIGATION IN ANIMAL HUSBANDRY FOR THE YEAR 1906.

1. A comparison of the different systems of *wintering steers in Colorado.* The plan is, in brief, to select sixty uniform steer calves from three different parts of the State at weaning time this fall, fifteen of them from a ranch on the western slope, a like number from a ranch on the plains, and thirty head from a ranch on the eastern slope of the foothills. Five of these calves from the plains, five from the western slope and ten from the ranch in the foothills will be brought to the Experiment Station this fall and put on feed. The remaining ten steers on the plains will be wintered almost entirely on the range; the remaining ten steers on the western slope will be wintered with the ranchman from whom they were purchased, on a combination of range and hay feeding, while the remaining twenty steers of the lot selected on the eastern slope of the foothills will be wintered entirely on native hay.

Next fall, five more of these steers from the western slope, a like number from the plains and ten head from the foothills of the eastern slope will be brought to the College and put on similar feed to that given the first three lots, and the succeeding fall the remaining twenty head of the three lots will be brought here and put on feed until ready for market as three year olds.

The object of this line of work is to compare the different systems of wintering cattle, as it affects the cost of beef production, the quality of the meat, and the development of the animals generally.

2. A comparison of roots, hay and grain with hay and grain alone for wintering steer calves.

3. The value of sugar beets in fattening young pigs. In this experiment we will use twenty-four young shoats. Twelve of these will get a mixture of ground corn, ground barley and wheat shorts. The remaining twelve head of similar breeding and like weight will get just half the amount of this same combination of feeds as the first lot received, with what sliced sugar beets in addition they will eat, the object being to determine the value of sugar beets in fattening pigs in comparison with an all-grain ration.

4. An experiment to determine the cost of wintering brood sows, and the effect upon the offspring of wintering brood sows on sugar beets and alfalfa hay, as compared with a grain ratio and alfalfa hay. We will have ten head of brood sows available for this experiment. Five of these will be fed sugar beets and al-

falfa hay, and the others will have a mixture of grain for a ration, and alfalfa hay.

W. L. CARLYLE,
Agriculturist.

ASSISTANT AGRICULTURIST.

GRAINS AND GRASSES.

PLANS FOR YEAR.

I. Grain Investigation Work.
II. Forage and Grass Investigation Work.
III. Sugar Beet and Other Root Investigation Work.
IV. Seed Competition Work.
V. Publication of Data Obtained.

VETERINARY SECTION.

PLANS FOR YEAR.

(1) To continue the investigation of loco weeds and disease in conjunction with the Department of Agriculture.

(2) To investigate poison weeds other than loco and contagious diseases in general over the State.

(3) Printing of bulletin on Larkspur and Other Poisonous Plants.

ARKANSAS VALLEY FIELD AGENT.

Alfalfa, Beets and Cantaloupes. The specific lines of each as follows:

Alfalfa. 1. Improvement by seed selection, extending the present nursery, with planting of seed selected this year, and other promising strains. This work to be done in co-operation with Prof. Olin.

2. A field study and the investigation of conditions and methods of securing the best yields of alfalfa seed. This work might be planned to complete for an early publication, also with a view of extended investigation, if the results warranted.

3. Continued co-operative work with Prof. C. P. Gillette investigating the insects injuring alfalfa, especially affecting seed production.

Beets. The continuation of the efforts to develop a disease resisting beet. Also a similar outline for investigating beet seed growing as that planned above for alfalfa, though the field for observation might be smaller. The two lines could be worked in conjunction.

Cantaloupes. 1. Continuation of the rust-resisting cantaloupe investigation; this could largely be done in co-operation with growers. Perhaps a small plot on the Station property.

2. Improvement of cantaloupe by cross-breeding small test plot.

The general plan to carry out the above line of work would be field work in the vicinity of Rocky Ford and plat work on the Station property at Rocky Ford. The field work also to include several trips up and down the Arkansas valley to investigate alfalfa seed growing. Possibly a trip as far east as Garden City, Kansas, which is a large alfalfa seed producing section.

The investigation of beet seed growing is one of large interest to the State, and to what extent it should be taken hold of is a question better considered than recommended.

I. THE CANTALOUPE INDUSTRY IN THE ARKANSAS VALLEY.

To take up this, and especially the question of Farmers' Co-operative Organizations; to obtain complete data of the original cause of organization; developments from year to year; methods of organization and changes that have taken place, together with results; to obtain data as complete as possible by correspondence and by records, with the idea of issuing as one of a series of bulletins on the Farmers' Co-operative Organizations.

II. STUDY OF CULTURAL METHODS OF SUGAR BEETS.

To take up the methods of growing beets in the Arkansas valley; to spend a great deal of time in the field visiting the beet fields with the agricultural men of the different factories; to especially study the difference in cultivation and yield, and to trace them back to the cause which may have produced them.

To take up more especially in this connection the Arkansas valley as about as much as can be done in one season, but to make several trips into the beet growing sections and other parts of the State, and to give to this matter the time available from the cantaloupe and alfalfa investigations to be carried on at Rocky Ford.

PHILO K. BLINN.

FINANCIAL REPORT OF THE COLORADO AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING JUNE 30, 1906.

RECEIPTS.

Dr.	U. S. Fund	Special Fund	State Fund	Totals
From the Treasurer of the United States as per appropriation for the fiscal year ending June 30, 1906, as per act of Congress approved March 2, 1887	$15,000.00	.....	.....	.....
Balance on hand July 1, 1905	.....	$ 686.05	.....	.....
Miscellaneous	.....	2,588.23	.....	.....
*State appropriations	.....	.....	$14,000.00	.....
Total receipts				$32,274.28

DISBURSEMENTS.

Classification	U. S. Fund	Special Fund	State Fund	Totals
Salaries	$10,234.50	$ 1,168.29	$ 180.00	$11,582.79
Labor	446.70	287.95	963.73	1,698.38
Publications	1,677.52	997.78	503.60	3,178.90
Postage and stationery	379.42	39.79	258.98	678.19
Freight and express	129.41	21.16	247.82	398.39
Heat, light, water and power	4.35	5.70	.....	10.05
Chemical supplies	.....	.....	.....	.....
Seeds, plants and sundry supplies	226.95	22.88	630.07	879.90
Fertilizers	.....	.....	3.10	3.10
Feeding stuffs	.....	.....	541.37	541.37
Library	169.27	26.00	.....	195.27
Tools, implements and machinery	.....	18.65	38.80	57.45
Furniture and fixtures	494.42	134.60	33.80	662.82
Scientific apparatus	236.11	242.79	72.79	551.69
Live stock	110.00	.....	1,679.63	1,789.63
Traveling expenses	807.52	260.61	320.19	1,388.32
Contingent expenses	83.83	35.00	6.00	124.83
Buildings and repairs	.....	13.08	6,155.60	6,168.68
Total expended	$15,000.00	$ 3,274.28	$11,635.48	$29,909.76
Balance			2,364.52	2,364.52
			$14,000.00	$32,274.28

*This is a special appropriation by the State Legislature for two years—from December 1, 1904, to November 30, 1906, inclusive.

INVENTORY, AGRICULTURAL EXPERIMENT STATION, 1906.

DIRECTOR'S OFFICE.

Office fixtures and equipment	$ 1,689.38	
Stationery and supplies	417.85	
Half tones and zinc etchings	455.70	
Library	2,410.00	
		$ 4,972.93

METEOROLOGICAL AND IRRIGATION ENGINEERING SECTION.

Meteorological instruments	$ 701.55	
Office fixtures	254.95	
Stationery, books, maps, etc.	56.65	
Irrigation and hydraulic apparatus	449.80	
Photo supplies and negatives	262.19	
Tools, etc., for soil work	180.85	
Miscellaneous	367.18	
		$ 2,273.17

ENTOMOLOGICAL SECTION.

Laboratory and office supplies	$ 329.53	
Entomological supplies	140.90	
Insecticides and insecticide apparatus	283.10	
Apiary	118.45	
Microscopic apparatus	592.25	
		$ 1,464.23

CHEMICAL SECTION.

Calorimeter	$ 210.00	
Polariscope	180.00	
Pulp machine and juice press	70.00	
Three balances	250.00	
		$ 610.00

HORTICULTURAL SECTION.

Photographic apparatus	$ 64.35	
Instruments	114.00	
Herbarium	1,652.00	
Tools	30.80	
		$ 1,861.15

AGRICULTURAL SECTION.

Implements and tools	$ 485.50	
		$ 685.50

VETERINARY SECTION.

Kodak	$ 18.00	
Stationery	2.00	
Stock at Hugo (loco experiment)	408.00	
		$ 428.00

ROCKY FORD SUB-STATION.

Forty acres of land, with water rights (title conditional)	$ 7,000.00	
Buildings and improvements	1,484.00	
Farm machinery and tools	678.75	
Office furniture and fixtures	30.80	
Camera and photo supplies	30.00	
		$ 9,223.55

CHEYENNE WELLS SUB-STATION.

One hundred and sixty acres of land (title conditional)	$ 800.00	
Fencing	110.00	
Three thousand feet galvanized iron pipe, in ground	30.00	
Dwelling house and barn	750.00	
(U. P. Railway property at station, $18.)		$ 1,690.80

WESTERN SLOPE FRUIT INVESTIGATION.

Horse	$ 110.00	
Implements and tools	136.50	
Office furniture and fixtures	157.35	
Camera and photo supplies	69.40	
Sprayers	100.00	
Insecticides	3.25	
		$ 576.50

Total	$23,785.83
Total Adams Fund inventory	4,157.36
Total	$27,943.19

REPORT OF THE HORTICULTURIST AND BOTANIST.

To the Director:

Since my last report the work in this section has been divided into several sub-sections, as follows:

Forestry, in charge of Prof. B. O. Longyear.

Western Slope Fruit Investigations, in charge of Prof. O. B. Whipple.

Potato Investigations, in charge of Mr. E. R. Bennett.

Professor Whipple, formerly assistant in Horticulture, was placed in charge of the work on the Western Slope, leaving here in April. His successor, Professor Paull, did not assume his duties until September, consequently the work here has been considerably hampered.

Mr. Bennett began his work with potatoes in April. It is too soon to expect definite results from this work, however; a number of interesting experiments are well under way.

Perhaps the most important departure which the College and Experiment Station has yet undertaken so far as the Horticultural section is concerned is the inauguration of field work on the Western Slope. Both Mr. Taylor and Mr. Whipple have met with good results with their work, and the constant demands on their time shows that the efforts of the College are appreciated.

More detailed accounts of the work of these various sub-sections will follow.

Our own time has been largely occupied with teaching, executive work, correspondence and occasional visits to the fruit sections of the State. A new plant disease has made its appearance in the form of a bacterial blight of alfalfa. This disease appears to be new to science, and in some restricted localities has resulted in the practical destruction of the crop. We have planned to make a thorough study of the disease and hope to discover some method of combatting it.

Material for two bulletins has been collected, as follows: "Fruit Associations" and "The Red Raspberry Industry." We hope to have these ready for publication before the close of the year.

Forestry. A co-operative experiment in tree planting was begun last spring, which originally included twenty farmers in as many localities. Twelve thousand trees were to be distributed in lots of six hundred each. But the demands for trees were so great that the plans were extended till forty-seven co-operators included and 22,200 trees distributed. Reports from these men show that in the great majority of instances these trees have been well taken care of and a good growth is the result.

Potato Investigations. Mr. Bennett began his work with potatoes in the latter part of April. He has visited all of the potato growing sections of the State, and made a systematic study of the culture of the crop and the general status of the industry. A bulletin on this phase of the work is now in preparation.

Several experiments in seed selection in an effort to produce more uniform and more stable varieties are well under way.

Western Slope Fruit Investigations. This work was inaugurated last spring by the appointment of Mr. O. B. Whipple as Field Horticulturist, and Mr. E. P. Taylor, Field Entomologist. I need only mention here that this work has proven most satisfactory from all standpoints. The demands for advice and assistance in various ways have been greater than could be met, even had no experimental work been attempted. The results of one season's experiments are not usually conclusive, but some of the things which these men have determined even in this short time will be worth many thousands of dollars annually to the fruit growers of Grand valley.

Respectfully submitted,

W. PADDOCK,
Horticulturist and Botanist.

SUB-SECTION OF WESTERN SLOPE FRUIT INVESTIGATIONS.

My work in connection with the Station as Field Horticulturist dates from April 1, 1906, and practically all of this time has been devoted to the study of orchard conditions in Mesa county. During the season I have made two trips to Delta county to investigate the conditions there. I find it nearly, if not quite, impossible, to divide my time to any great extent with outside counties.

In my work I have given especial attention to plant diseases, cultivation, watering, pruning and the collection of data on the fruit industry.

The interest taken in the work by the growers has been very gratifying, and at no time have we experienced any difficulty in securing the co-operation of careful growers in carrying on experiments. The success of our work depends to a large extent upon this friendly co-operation of the fruit growers. Our correspondence with growers has not been all we desired, but will no doubt increase as we become better acquainted and the plan of our work better known. Requests for information have been numerous, but, on account of the limited time spent in the office, some growers have no doubt become discouraged in trying to catch us by telephone. We have tried to spend as many evenings as possible in the office, where we hope the growers will learn to catch us.

The orchard survey work has not progressed as rapidly as we at first hoped it would, on account of the time required for other investigations. This survey work has been carried on in connection with other work as far as possible. This part of the investigations can no doubt be pushed more rapidly during the remainder of the year, and while the summer season is no doubt the ideal time for this work, I think the object of the survey can be accomplished during the winter season.

Observations on plant diseases have been very interesting, and some important conclusions have been reached.

In three orchards where experiments were carried on in spraying for Alternaria very satisfactory results were obtained. Bordeaux as a fungicide was used in connection with arsenate of lead and arsenite of lime, being careful in each case to have some check trees where the effect of these insecticides on the fruit and foliage when used alone might be observed. These experimental blocks contained Kieffer pears and Gano and Ben Davis apples, and were so divided as to show the possibility of controling Alternaria with one winter application, with one winter and one summer and with two summer applications of Bordeaux

mixture. For all summer applications half strength Bordeaux was used, and were with the first and second codling moth sprays. The following conclusions were reached:

That Alternaria is, in most cases, a secondary factor in causing the decay of fruit, and in this locality at least follows spray injury to a large extent, though it may follow bruising or codling moth injury.

That the most satisfactory method of controlling it lies in choosing a reliable arsenical poison.

That the Kieffer pear can not, in this locality, be sprayed with any degree of safety with other than a standard or tried brand of arsenate of lead.

That if Ben Davis and Gano apples are to be sprayed with arsenite of lime, special care should be given to its preparation, and a good clear day selected in which to apply it.

As a secondary observation it is found that Bordeaux mixture prepared by using two pounds copper sulfate, four pounds lime and fifty gallons of water will russet Ben Davis and Gano apples, though not to any serious extent, if used on any other than a clear day, and even then russeting may occur on the shaded portions of large trees.

Though only a trace has been found in this county, peach mildew has attracted more attention than usual in other localities this season. This is probably on account of the unusual amount of rain during the early part of the summer. No experiments have been carried on under my directions, but observations made in orchards sprayed by careful orchard men show that one thorough summer application of dilute Bordeaux, 2-4-50, will clean up a badly infested orchard. The disease is capable of ruining a crop in a short time, and prompt action is an important point in fighting this disease.

Gummosis in peach trees has been called to my attention in several orchards, and where not too far advanced, a vertical slitting of the bark seems to bring relief and leads to the recovery of the tree. The use of a sharp knife in cutting through the bark about the affected trunk or branch seems worthy of further trial.

Two apparently distinct forms of root rot found working upon the apple seem to be important enough to require careful study the coming year. One form which is proving the more destructive of the two works exculsively, I believe, on the apples of the Ben Davis type, while the other shows no preference for varieties nor is its presence in the orchard followed by such rapid spread and destruction.

Some experiments have been undertaken in thinning apples to determine the average amount of fruit trees of various ages will produce and the effect of thinning out the color of the remaining fruit and the crop of the ensuing year.

Problems for the ensuing year I believe are:

Pear blight and its control, giving special attention to the form known as blossom blight.

Peach mildew and the effects of winter spraying with Bordeaux mixture and lime-sulphur washes.

Grape mildew (U. spiralis) and methods of control.

Tests in pruning grapes by various methods in hopes of finding a trellis method of training which will hold the fruit off the ground and still allow of the grapes being taken down and covered in winter.

Observations on the amount of irrigation best adapted to grape growing.

And a careful study of the two forms of root rot mentioned above, to determine the nature of the disease and remedies if possible.

Respectfully submitted,

O. B. WHIPPLE,
Field Horticulturist.

SUB-SECTION OF FORESTRY.

A CO-OPERATIVE EXPERIMENT IN TREE PLANTING.

An extensive experiment in co-operative tree planting has been started during the past season, with two species of utility trees—the Common or Black Locust (Robinia pseudacacia) and the Hardy, or Western Catalpa (Catalpa speciosa).

The primary purpose of the experiment is to enable us to secure data as to the adaptability of these two species of trees in different parts of the State, and furthermore to place object lessons in the formation of artificial timber plantations before the farmers and land owners of Colorado.

To this end notices were sent to the newspapers throughout the State, calling attention to the desirability of planting trees for posts, poles and fuel and calling for volunteers to co-operate with the Station in the experiment. To each volunteer was sent a printed leaflet giving the purposes, conditions, and plan of the experiment together with some suggestions for preparing the land and setting the trees for a timber lot. Each applicant for trees was also asked to give the altitude and a description of the land, the use of which was offered for this purpose.

According to the conditions of the experiment, as originally planned, each co-operator should furnish the land free of charge, plant the trees and care for them according to instructions, and report upon their condition whenever requested. The Experiment Station should furnish the trees free of charge, except transportation charges, and give occasional supervision and advice as to their care. It is intended to carry the experiment over a period of ten years, at the end of which time the Station will relinquish all claims upon the plantation.

At first it was planned to establish one plantation of three hundred trees of each species in each of twenty representative localities of the State. For this purpose six thousand trees of seedling locust and an equal number of two year old catalpas were purchased in 1905, and planted on the Station grounds, where they were allowed to grow one season. So many applications were made for trees, that it was impossible to supply all from this stock. An extra appropriation, however, was secured by which enough additional stock of the locust was purchased to supply 500 trees to such of the other applicants as seemed to be favorably situated for the purposes of the experiment. In all forty-seven lots of trees have been placed in the hands of co-operators representing thirty-five different localities and twenty-four counties.

Before shipping the trees, Press Bulletin No. 25, Instructions for Co-operative Tree Planters, was prepared and sent out.

This contains detailed instructions as to location, and preparation of the soil, spacing, heeling in, trimming, planting, irrigating and cultivating.

The catalpa seedlings, when planted on the Station grounds, were two years old, and about eighteen inches high. They were cut back to about one foot in length, and after being root pruned, were planted with ditching spades in rows two feet apart. The locust seedlings were only about one foot long when received and were cut back and planted in the same manner as the catalpas. The catalpas made a growth of about ten to fifteen inches; the locusts an average of about four feet. During the winter of 1905 and 1906, which was very severe on all young trees, both species were killed back nearly to the ground; the locusts being less injured than the catalpas.

The second lot of locust seedlings, purchased in the spring of 1906, were of vigorous growth and about two and three feet high. They were shipped from the nursery to the Station where they were divided into lots of 500 and baled for shipment to the planters.

Respectfully submitted,

B. O. LONGYEAR,
Assistant Botanist.

SUB-SECTION OF POTATO INVESTIGATIONS.

The investigation of the potato industry in Colorado was begun the latter part of April, 1906. Since then the various potato districts of the State have been visited, and a systematic study has been made of the methods of culture, irrigation, insect pests and diseases of the Greeley district and the other districts as far as time has permitted.

Experiments to determine the effect of changing seed from one location to another have been started. Two sacks of Red Improved Peachblow potatoes were selected from the storage cellar of Mr. Edgerton, of Carbondale. One of these was planted there. The other was sent to Greeley and planted on Mr. E. R. Bliss' place, near Greeley. Two sacks each of Late Ohio, White Pearl and Rural New York No. 2 were selected from bins at Greeley, one of which was planted there, while the others were sent to Carbondale and planted.

The work of improving and fixing the existing varieties by selection has been started in co-operation with potato growers in different places. A quantity of a new variety from Scotland, the Delmany Beauty, which is being grown by Mr. Grubb, at Carbondale, was divided into two types, one a round potato, the other long, and planted separately to observe the effect on the types.

Ten sacks of White Pearl potatoes have been selected from a field on the farm of Mr. Bickling, near Greeley, and stored in his cellar. The potatoes in this field were of a superior type to most fields, owing to the effects of two years' careful selection by the grower. Many hills contained potatoes, all of which were of a desirable type. None but the best tubers from these desirable hills were selected. Because of the tendency of potatoes to "run out" when planted more than two or three years on the irrigated land of Greeley, growers do not keep the same seed more than that time, and by changing, the gain from the two years previous selection is lost. The plan is to have these selected potatoes planted on the unirrigated land of the Arkansas divide, and at the end of one or two seasons, bring them back to the Greeley district. If this should prove to be practical, the type of potatoes can be much improved.

It is thought possible by careful selection to avoid the tendency of potatoes to "run out" on the irrigated lands. With this idea in mind, seven sacks of potatoes were selected from a field of new land on the same farm near Greeley. These were grown from Divide seed, which, like most seed brought from outside the district, is mixed as to variety as well as type.

Of the Improved Peachblow potatoes brought from Carbondale, one sack has been selected for seed for next year and a sack of Carbondale seed will be planted with them so as to observe the effect of the acclimatization on them.

One acre of land on the Foy place, two miles east of Fort Collins, was rented for experimental work with potatoes. The land was planted with small plats of about fifty varieties of seedlings and European varieties, obtained from the Department of Agriculture at Washington. The formalin and corrosive sublimate treatment were both used on plats of Pearls and Rural New York No. 2, and one plot of the land was given an application of copper sulphate at the rate of 35 pounds per acre to ascertain the effect on potato scab or *Rhyzoctonia*.

Measurements have been made as to the amount of water used by irrigation to grow an acre of potatoes. Special attention has been give nto the diseases of potatoes, especially *Rhyzoctonia*, as to its effect on yield and quality of the crop and to the conditions of culture and irrigation that have tended to make the disease less or otherwise. Investigation along the same line is now being carried on in the laboratory.

It is the opinion of the writer that cultural methods have much to do with the control of our soil disease, and consequently the success of the potato crop. It is proposed to carry on quite extensive experiments in co-operation with growers in different parts of the State to determine the effect of deep versus shallow cultivation.

Respectfully submitted,

E. R. BENNETT,
Potato Expert.

REPORT OF THE ENTOMOLOGIST.

Fort Collins, Colo., Nov. 24. 1906.

To the Director:

I have the honor to present herewith my annual report of the Entomological Section for the year just closing.

The year has not been marked by any extraordinary insect outbreak unless it be the rapid increase of the green aphis and the woolly aphis of the apple tree in the orchards of the Western Slope where these insects have become an intolerable burden to the apple growers. If these lice continue their depredations unabated for a few years more in the sections where they have been most abundant the past year, there are many fruit growers who will feel like giving up the fight and taking out their apple trees.

Rather extensive experimental work has been outlined with a view to finding better methods for the control of these pests. The work includes a thorough study of the life histories and natural enemies of these insects as well as the testing of insecticide measures for their destruction.

The melon louse (*Aphis gossypii*) continues to be a serious pest in those sections of the State where water melons and cantaloupes have longest been grown in a commercial way. This insect is also a special subject of study by this section, both for the purpose of determining its food habits, and life history as well as to determine the most practical methods of keeping it in check in the melon fields. Considerable has been accomplished along this line already but our work must continue through another year at least before publishing upon it.

While the three plant lice above mentioned are being given special attention, it is thought best to do as much as possible to determine the species of plant lice that are infesting Colorado plants, both native and cultivated, and to determine, so far as possible, their life histories.

Two papers are about ready at the present time for publication upon the plant lice of the genus Chermes attacking Colorado Conifers.

The common grasshoppers (Locusts) have been usually abundant over the State the past summer and the Western cricket (*Anabrus simplex*) is reported to have done many hundreds of dollars damage to crops in Routt county the past year. The depredations are carried on at so great a distance from the Experiment Station that it makes the work of experimentation against this insect very expensive, and nothing has been done in the study of its habits or to determine the best methods for its destruction by this section except what was published in Bulletin 101. If the depredations of this insect continue, it will doubtless be ad-

visable to arrange to take up some special lines of investigation with a view of finding better remedies than are at present known to lessen its injuries.

The work of collecting the economic insects during the past year has been very largely confined to the plant lice and the insects that are associated with them either as friends or enemies.

The only scale insects of much economic importance in Colorado are the cottony maple scale, attacking chiefly the soft maple, the boxelder, and the black locust, and Howard's scale (*Aspidiotus Howardi*), most abundant upon pear, plum and apple trees. The work of the section upon the former scale was reported by Mr. S. A. Johnson in Bulletin 116 and press bulletin 27, and Mr. E. P. Taylor has been giving special attention to Howard's scale in the orchards of the Western Slope where it has been injuriously abundant in many instances to a small number of trees. Mr. Taylor expects to be able to prepare a bulletin giving full life habits and satisfactory remedies for this insect in the near future. He probably will wish to carry his investigations through another year, however, before making his report upon the work.

The oystershell scale (*Lepidosaphes ulmi*) was first taken in the State by Mr. S. A. Johnson the past year, who found it badly infesting a few lilac bushes in City Park, Denver. Mr. L. C. Bragg has since taken the same scale in several instances upon elm trees in the vicinity of Fort Collins, but in scattered numbers only in each case.

I am glad to be able still to report that the San Jose scale continues to be unknown in the orchards of Colorado.

The peach twig borer (*Anarsia lineatella*) did its usual injuries to peach trees of the Western Slope last spring. Mr. E. P. Taylor seems to have demonstrated that the injuries of this insect can be almost entirely prevented by an early spring application of arsenate of lead.

The Eastern peach borer (*Sanninoidea exitiosa*) has also been found by Mr. Taylor to be a serious pest in a few limited localities on the Western Slope. It has not as yet attracted much attention as an injurious insect in this State, but the fact that it is already injuring a few orchards, makes it important that our fruit growers be very watchful and put forth every effort to keep this serious peach enemy in check.

The observations upon fruit blossoms, and the time of the blooming of our fruit trees, that have been carried on for two or three years past are being made chiefly for the purpose of determining the relation of the varieties of fruit to the time for spraying, and to determine the flower visitants and their possible or exact relation to blight in apple and peach orchards. Considerable additional data have been collected during the past year. All of these records with additional ones, I hope to be able to collate for publication some time in the future.

The co-operative experiment with the Horticultural Section for the special purpose of determining whether or not blight

germs are carried over in honey in the bee hive is also being continued for another year.

The codling moth work that was planned for the Western Slope and which was carried on in a section where this insect had become specially destructive and abundant, were carried through by Mr. Taylor to a satisfactory conclusion, proving beyond reasonable doubt that this insect can be almost wiped out as an orchard pest in the worst infected sections of the State by two or three thorough applications of Arsenate of Lead properly applied. (See the report of Mr. Taylor given below.)

Mr. Taylor has also carried through life history records upon this insect the past season that confirm the writer's former views as to the number of broods of the moth and that will be of much value in determining the best dates for the application of arsenical sprays for the control of this insect in the Grand Valley.

Mr. Johnson's investigations of loco insects have been completed and a short bulletin can be prepared soon.

The work upon potato insects, which is also being carried on by Mr. Johnson, will need to be continued through another season.

The entomological outline from this section for the Western slope fruit investigations for the years 1906-'07 is as follows:

I. NOTES ON APPLE AND PEAR BLOOM—

A. In relation to Codling moth spray.
   (a) Date of blooming of different varieties.
   (b) Date of petals falling from different varieties.
   (c) Date of calyx closing in different varieties.
   (d) Relation of early and late blooming to setting of fruit.
   (e) Position of calyx cups, up, out, down, etc.

B. Relation of bees and other insects to blight.
   (a) Proportion of honey bees to all other insects visiting apple and pear blossoms; also collect and pin examples.
   (b) Note condition of bloom when bees stop work.

II. SPRAY NOTES.

A. Kind of poison.
   (a) Compare arsenate of lead and arsenite of lime.

B. Comparative value of different sprays at different dates.
   (a) Once as blossoms fall.

(b) As blossoms fall and again in 30 days.
(c) As preceding and again in 30 days.
(d) As preceding and again in 30 days.
(e) As preceding and again in 30 days.
(f) As preceding, except that first spray (a) is to be left out.

Also note size of trees, amount of spray used, varieties, pressure, etc.

III. LIFE HISTORY NOTES. (Codling moth.)

A. Band record on at least ten trees. Observations not less than once a week.

(a) Try to determine when first eggs are laid, and when first worms enter apples, what per cent enter bloom on sprayed and unsprayed trees, the date of minimum of worms between broods. When second brood of worms begin to come down, when first brood are all down, etc.

(b) By cutting open unsprayed apples wormy by the second brood, determine what per cent really enter at blossoms.

B. Make notes on the work of others bearing on above points, the time and thoroughness of their spraying, etc.

IV. MISCELLANEOUS NOTES.

A. Woolly Aphis.

(a) Varieties most and least attacked.

(b) Extent of injury (little apples, trees killed, etc.); when first winged lice appeared, effects of the remedies that have been used, etc.

B. Howard Scale (and others).

(a) Kind of scale, variety attacked, nature of the attack, extent of injury, when first noticed, stage of insect. Notes on applications that may have been made.

C. Peach Twig Borer.

(a) Fruit tree attacked, nature and extent of injury. Try to determine broods, collect under bands. Notes on remedies.

D. Western Peach Borer.

(a) Rear all specimens possible to determine life history.

E. Apple Aphis (and others).

(a) Note if lime and sulphur or other sprays before hatching lessen lice.

F. Brown Mites.

(a) Same notes as for preceding.

G. Such other miscellaneous notes as seem to you to be of value.

Special emphasis was put upon the codling moth work during the spring, summer and fall of 1906. A greater portion of that investigation having been satisfactorily completed, and the woolly aphis and green aphis having become the two most serious pests on the Western Slope, the principal work for the coming year will be with these two lice. Such time as is unoccupied with this investigation will be devoted to carrying on other work outlined in the schedule.

I believe we are very fortunate in securing so good a man as Mr. Taylor to carry on the entomological work in the orchards of the Western Slope, and I very much hope his services may be continued another year.

The plant lice investigations of the Western Slope are only a portion of a larger scheme for the study of the habits and life histories of Colorado aphididæ to be carried on from the Central station.

The bulletins published from this section during the year just closing are No. 114, Insects and Insecticides, C. P. Gillette; No. 116, The Cottony Maple Scale, S. A. Johnson, and press bulletin No. 27, The Cottony Maple Scale, S. A. Johnson.

I am also appending a report from Mr. E .P. Taylor, entomologist of West Slope Fruit Investigations, and an index to the entomological writings of the station from its organization to the present time, all of which is

Very respectfully submitted,

C. P. GILLETTE.

REPORT OF FIELD ENTOMOLOGIST.

To the Director:

I herewith report the results of work of the field entomologist of the Western Slope fruit investigations for the year 1906.

The lines of research outlined as a guide by the Entomological Department of the station at the beginning of my duties have been adhered to as closely as possible, with an occasional broadening or deviation of experiments and investigations as the conditions of the situation presented new possibilities.

The principal lines of work for the season have been as follows:

1. Experiments upon practical methods of controlling the principal insect pests of the orchard.

2. The collection and study of other economic insects.

3. Visitation of orchards by request or otherwise.

4. Attendance at fruit growers' meetings, farmer's institutes, county fairs, etc., where questions relating to the work of this office were being considered.

The experiments conducted upon economic insects have been carried on in co-operation with the orchardmen themselves who are suffering losses from these pests. These experiments have been as practical demonstrations in each neighborhood in which they were carried on and have served as object lessons at the same time they were revealing new facts. They have been the objects of the deepest local interest. These co-operative experiments have in general proven most successful and beneficial, as evinced by the hearty support and appreciation shown. The territory covered by the demonstrative experiments has been thus far limited to points lying in the lower Grand valley, principally in the orchard sections surrounding Grand Junction, Palisade and Fruita. Numerous requests for such work have been received from other fruit sections of the Western Slope. These districts wish to have similar investigations planned for them.

The codling moth has received the greatest share of attention. Spraying experiments have been completed in five orchards of the valley, and the results successfully answer the principal questions which were being asked by orchardmen at the beginning of the season. These results, among other things, have demonstrated the fact that this important pest may be controlled by a fewer number of sprays than have ordinarily been given in this locality. The proper time to spray has been determined as well as the proper spray materials and the right way in which to do the spraying. The life history of the codling moth for this section

has been studied and the method of spraying against it planned, with the life history and habits of the moth in view.

Probably no district in the United States is better equipped with modern spraying appliances than the orchard district of Grand valley, but in spite of this fact codling moth ravages have injured the fruit of the one locality to the extent of a great many hundreds of thousands of dollars each year for some years past. This was done in spite of the fact that many orchardists gave eight or ten or even more sprayings per season. It has been determined that these failures have been due to several causes: (1) lack of thoroughness of method; (2) lack of proper spray material, and (3) lack of knowledge of the exact life history of the moth enabling them to apply their sprays at the most effective time. At Fruita experiments were conducted determining the proper time to spray, resulting in practical control of the moth in badly infested orchards with from two to three applications. In the experimental plat of this orchard sprayed three times with Swift's arsenate of lead a count of 3,971 Ben Davis apples, picked from average trees, gave but 1.8 per cent. wormy apples; from 137 Jonathan apples, from trees receiving the same treatment, 2 per cent. were wormy, and 2,683 apples from Winesap trees of the same plat gave only 1.19 per cent. wormy. Out of 4,818 Jonathan apples picked and examined from trees sprayed five times, only 99/100 of one per cent. were wormy, while picked apples from unsprayed Jonathans in the same orchard gave 78.1 per cent. wormy apples, and the majority of the crop had fallen to the ground as wormy wind-falls previous to the count. At Grand Junction the codling moth experiments were conducted upon the proper methods of application of spray; comparative values of arsenate of lead and arsenite of lime as a spray and the comparative merits of different formulæ of these insecticides. These experiments were conducted along practical lines, with economic results in view. Great pains were taken to make the tests upon an extensive practical basis in order that the results would represent the greatest accuracy possible. In obtaining the exact outcome of the work, very large numbers of apples have been given careful hand to hand inspection, as it seemed that only averages from large numbers of apples could accurately represent the true condition. In determining the codling moth percentages, over 100,000 apples were critically examined, representing upwards of 600 boxes chosen as the nearest types of the various plats under comparison. The examination and counting of this number of apples has been in itself no small task, but the results seem to more than justify the time and labor spent.

Experiments conducted at Palisade have demonstrated the great value in the use of arsenate of lead against the peach-twig borer which has caused damage to the peaches of that section.

The life history of the Howard scale of the pear has been partially worked out and the insect successfully and cheaply controlled by dormant sprays of the lime and sulphur wash. The

mite of the pear has likewise been experimented upon and a similar treatment found successful. The peach borer has been found present and experiments for its control are under way. The unusual abundance this season of all forms of aphids has made it necessary to devote some time to their injuries and treatment. A number of insecticides were tested in April against the eggs of the insect then hatching and the lime and sulphur wash found destructive to their eggs. Experiments of insecticide against the woolly aphis so universally destructive are now under way. A new injury to the tender buds of pear and apple by a minute chrysomelid beetle (*Myochrous squamosus* Lec.) was discovered and studied and some measures of control undertaken. The microscopic bee (*Trichogramma pretiosa*) infesting the egg of the codling moth was studied in relation to its benefit in our apple and pear orchards in assisting in the control of this insect. Studies were made also of lace wings and lady beetles, which are so helpful in reducing the number of woolly aphis and other aphids. Injury by ants and prairie dogs to young cantoloupes planted upon virgin land has been observed and assistance given in their control. The injury to fruit from sprays containing an excess of free arsenic has been fully investigated and is now under preparation for fuller report. Other miscellaneous notes have been made upon peach aphis, elm aphis, mosquitoes, green fruit worm, grasshoppers, round head borers, etc., and considerable material collected and preserved. An insectary for the study of life histories of insects has been maintained throughout the season.

Various new insecticides have been tested, some where the fruit growers' association desired information upon such products before making large purchases of them. In all my work an intimate and beneficial relation between the associations of fruit growers has been maintained.

Notes on fruit bloom in relation to sprays have been collected, such as the date of blooming of different varieties, the date of petals falling from different varieties, date of calyx closing, relation of early and late blooming to setting of fruit, and the direction of fruit bloom upon the tree.

An exhibit of the entomological work being done was prepared and shown at the local county fairs, attracting considerable attention.

A considerable number of horticultural meetings have been attended. Short addresses upon subjects relating to the work have been given at seven meetings held throughout the fruit sections of Mesa county by fruit growers' associations or horticultural societies. Aside from these some part in regular farmers' institute work has been taken.

Respectfully submitted,

ESTES P. TAYLOR.

Grand Junction, Nov. 8, 1906.

REPORT OF THE IRRIGATION ENGINEER.

During the year, the work has followed the outline, and it together with the accumulated results of previous years, needs to be worked up to result in a number of bulletins.

The general topic of the irrigation survey of Colorado is one which has been the constant purpose of this section of the Station for a number of years, but the scope has been such that but little can be done from year to year. The special studies which have been made in Evaporation, in Duty of Water and in the Return of Waters, have been only separate steps which when completed will close into a whole.

The valleys of the Platte, the Poudre, the Arkansas and the Rio Grande have been quite thoroughly investigated.

The most time and expense this year has been given to the investigation of the draining of the lands near Grand Junction.

Because of the Western Slope fruit investigation, this investigation seems a timely one. A great many acres of valuable land in that community have become water logged and it has been therefore a matter of great economical importance to determine the remedy. The first and most important step in prescribing has been to be sure of the diagnosis. During the year careful and complete measurements have been made over an area of many square miles including the determination of the surface and ground water in the attempt to get at the source of the water and the reason for its action in separate cases. The study is not complete but leads to some manifest conclusions. One is, that the water is used in excess, and that a united system of drainage becomes necessary.

An interesting study has been made of a water system isolated from all others and where the conditions were especially favorable for a record of the water as applied, of the acreage and the other phases of the water. In most cases, the application of water from one ditch is so complicated from the effect of the water applied from other ditches that the study has to be taken up on too large a scale to be within our means of men and apparatus. This also is being worked up. The records in meteorology have been continued as before, and now with the nearly twenty-five years' record, they have become of much value for a knowledge of the climate. These records involve an enormous amount of time and labor but they are worth the time and cost. An intelligent study of the plant life can not be made without a knowledge of the portions relating to water.

The measurements of water developing in streams has been made for a number of hundred miles. They show the continued increase in the water which returns to the streams. It indicates

that the water thus coming to the Poudre, as a specific instance, has practically doubled in the past fifteen years, and that this increase means an increase of many thousands of acres as possible from the water supply of that stream. Where the other streams of the State are also included, it means the increase of several hundred thousands of acres in the Platte Valley alone.

These measurements with further extensions relating to the mutual relation of water and crops, which is a laboratory study, long wanted to be undertaken, we desire to take up at fuller length during the coming year.

In this work, we have had the efficient help of Professor House, Mr. Trimble, Professor Lorey, and Mr. F. L. Payne, to whom much credit is due.

Respectfully submitted,
L. G. CARPENTER.

December 1, 1906.

L. G. Carpenter, Director,
Colorado Experiment Station.

Dear Sir—The months of June, July and August were spent by the Assistant Irrigation Engineer in the Grand Valley upon the investigation of the seepage problem presented in that Valley.

Headquarters were established at Grand Junction. Holes six inches in diameter and running down to water were dug one-fourth of a mile apart and running on each section line from the ditch to the river. These lines of holes cover nearly the entire valley. A line of levels was run over the holes and accurate data has been collected of the depth of the surface water throughout the entire irrigation season.

Seepage measurements were taken on the Grand Valley Canal, the High Line Canal, the Mesa County Ditch, and the Independent Ditch.

The data has all been taken but it yet remains to tabulate this data, draw the maps, write up the conclusions, and an instructive bulletin ought to be the result.

The data collected seems to point to the fact that the seepage in the valley is due to excessive application of water in irrigating the land and is not due to the seepage from the main ditch. The remedy, of course, will be more economical use of water in irrigation, and the drainage of the worst seeped places.

Respectfully submitted,
E. B. HOUSE.

REPORT OF THE CHEMIST.

To the Director:

I herewith hand you my report of the work of the Chemical Section, covering particularly the period since my last report.

The only bulletin work completed is represented by the manuscript on the extraction and refining of beeswax and some analytical work requisite to the preparation of a small bulletin on the Australian salt bush, Atriplex semibaccata, and Russian thistle hay.

My reasons for the preparation of the latter material are essentially the following: In the eastern portion of this State, where the rainfall is small and stock raising is almost the only dependable industry, it is a question of considerable importance to the people that they should have a forage plant for hay-making which will not only make a good growth with a very small rainfall, but which will also furnish a relatively good fodder. The need of such a forage plant is so badly felt in some sections that the grass, locally known as sand grass, a dry, coarse, harsh grass, Russian thistle, and the native salt bush, Atriplex Argentea, have been used for this purpose.

In Bulletin 93 I recorded some experiments with hay made from the native salt bush, Atriplex Argentea, which while it is richer in the proteids than either corn fodder, timothy hay or native hay, and would, from the standpoint of Analytical Chemistry, be considered a fairly good fodder, and this judgment would not be gainsaid by a consideration of the coefficients of digestion unless those for the crude fibre and ash, the former being very low and the latter very high, should give rise to a question in regard to its value. The results of feeding for the short period of twelve days, however, showed that it is a very poor fodder—one whose use under any circumstances would probably be attended with more evil than good.

Concerning the Russian thistle hay, I have no data except such as I have gathered from individuals who have used it, which is, as a rule, of little value. There is, however, a substantial agreement that the thistle hay is of some value, though the claim made by some that it is very good is not to be accepted, as established.

There have been times in the eastern part of the State when any fodder at all for a few days would have saved the lives of many head of stock and it is to meet the exigencies of these short periods that energetic and provident persons have resorted to the expediency of using the fodders named. It is my belief that the Australian salt bush named is worthy of consideration in this connection and will probably furnish a source of fairly good fod-

der. This seems to me to justify the publication of a short bulletin on this subject.

The work in connection with my digestion experiments, is nearly completed and would have been wholly so before this had we not had our attention diverted to other work which would not so well admit of postponement.

The study of the deterioration of farm-yard manure, under our conditions is progressing as rapidly as the subject will permit. The practical importance of this work has become very much less than it was when we began it. The practice of our ranchmen up to a few years ago was irrational and wasteful in the extreme. This work was undertaken primarily to obtain data on this subject, which are at present wholly wanting, but it was hoped that its practical bearing upon our farm practice would be to correct this wastefulness and contribute to more rational treatment of our soils. The practical results hoped for have already been largely anticipated, due to a number of reasons but probably, most largely to the monetary returns obtained by fertilizing the land to be planted to sugar beets.

We have not been able to approach the new work which we planned for the very simple reason that we have been busy all the time, having more work than our present force can get done.

In regard to the study of the changes in the water used in irrigating the meadows of our mountain districts, the composition and digestibility of the forage grown under these conditions, I have nothing other to say than I have already put in writing. The subject is not wholly peculiar to Colorado, and has been studied, but not recently, so far as I know, and not under such favorable conditions as obtain here.

The subject presents, as it appears to me, some very interesting questions pertaining both to the water and the vegetation. But aside from these chemical questions, the marked economic results obtained in feeding, in the high parks of the State, for instance in North Park, invite inquiry into their causes, for these results are wholly, or in the main, obtained by the use of the native, mountain meadow hays, without the addition of grain.

The completion of the study of the waters, surface and underground, of the San Luis Valley is also awaiting us. The work which we did on these waters some years ago ought to be repeated and extended. The study promises some very interesting results pertaining to the changes which these waters undergo, both on the surface and within the strata composing the formation of the valley.

I have done very little, practically nothing, on the subject of alkali within the past year. Considerable material has been accumulated but the importance of the subject since our people have begun to drain their lands is less than formerly; another reason why I have not prosecuted further work on the subject is that I have found the character of our alkalies to be so nearly uniform that further addition to the already considerable number of

analyses seems to be useless. This subject of late years has become of some importance in the San Luis Valley and an extension of this study in connection with that of the waters of this valley might be worth the doing, otherwise I do not see any good reason for not considering the work completed.

We have done some miscellaneous work during the year covering quite a range of subjects. Such work takes a relatively large amount of time, often wholly disproportionate to its importance.

The requests for work of this character are quite numerous and though both the President of the College and yourself answer a number of these, we have received requests for one hundred and nine analyses in the past eight months, not counting requests from other sections of the Station. These requests are mostly for analyses of soils and waters, frequently specifying that a complete, thorough, correct or reliable qualitative and quantitative analysis is desired. It is simply impossible to consider these.

If we count a complete analyses, such as is frequently specified, of a soil or water, as requiring 60 hours work and we agreed to do one-half of the work requested within the last eight months, not counting the requests from other sections of the Station, we would have 3,000 hours' work or one man's time for 377 days of eight hours each—about 15 months' continuous work, counting 26 work days to the month. The department would either have to have two assistants for this class of work should we do all that is presented, or give up our station work proper.

The same considerations apply to a certain extent to work from other departments. It is a very easy matter to make work enough to keep twice my present force busy the whole year through. The chemical section is, as I understand it, supposed to be as independent as the other departments and as much independent work is expected of it as of any of the others. At the present time, I have but one station assistant on whose time I can depend for station work. I present these facts to make it clear that the chemical department can not accept much work of a miscellaneous character and carry on systematic work of its own.

In regard to the salary of Mr. Douglass, I recommend that he receive from January 1st, 1907, a salary of $1200.00 per year. I make this recommendation because Mr. Douglass is a willing and efficient assistant and deserves this recognition of his services, which have extended over seven years.

Respectfully submitted,

WM. P. HEADDEN.

Fort Collins, Colo., Nov. 14, 1906.

REPORT OF THE AGRICULTURIST.

To the Director:

I have the honor to submit the following brief report covering the work of investigation in the Agricultural Section of the Experiment Station.

Investigations in Agronomy.—The work in this division has been reported on very fully in the supplemental reports submitted herewith, prepared by Professor Olin and Mr. Knorr. The agronomy work is sub-divided into plant breeding, or field nursery work; co-operative experiments with selected farmers in various parts of the State, and cultural, seed selection and variety tests on the station farm. The plant breeding, or nursery work, has been directly in charge of Mr. Knorr, and the results obtained have been very encouraging for the first year. In this sub-division definite results can not be expected for a number of years.

In the co-operative work with the farmers the object has been to determine to what extent the results obtained by the farmers in all parts of the State would compare with those secured by the workers on the station farm, and also to introduce new varieties into the various sections, giving the farmers of that section an opportunity to study the characteristics and utility of the various grains, grasses and roots. This work has been carried on in forty-eight of the counties in the State and embraces all the varying conditions. We are very anxious to continue and to extend this work in the future and also to co-operate with the United States Department of Agriculture in the conduct of a dry land farm at Eads, on the Missouri Pacific railroad, in the eastern port of this State.

The station work proper, as reported by Professor Olin, has been greatly enlarged and developed on the new experiment farm. This work sub-divides into investigations in the various cultural methods for the growing of roots, grains and grasses; also the amount of water required by the various crops. In variety tests a vast amount of valuable work has been undertaken. Twenty-eight of the most promising varieties of oats were grown during the past season. One of these in particular yielded at the rate of 127 bushels per acre; twenty-three varieties of wheat, seventeen varieties of barley, nine varieties of peas, three varieties of corn, twenty-four varieties of sugar beets, nine varieties of rutabagas, four varieties of mangels, six of carrots and twenty-seven varieties of alfalfa were grown. A special effort is being made to secure varieties of grain with stiff straw and rust resistant characteristics for irrigated regions. Also drouth resistant varieties for dry farming conditions, and especially hardy varieties for higher altitudes. Already the new experiment farm is taxed to

its utmost in the conduct of this work. There is special need at this time for additional land where the most promising of these varieties of grains may be grown under field conditions where sufficient quantities may be grown for general distribution and for further testing under field conditions. To this end I would respectfully urge that the eighty acres of land lying immediately to the south of the Experiment farm, belonging to Mrs. Taylor, and upon which the College now has an option, be secured without delay for this purpose. The investigations now under way in alfalfa and sugar beets are especially valuable for the conditions prevailing in this State.

Investigations in Animal Husbandry.—The investigation started last year in the wintering of range steers on various rations is still being continued and its scope enlarged. In lamb feeding by the aid of College funds and through the liberality of one of our friends we are investigating the comparative feeding value of finely cut vs. whole alfalfa hay for sheep feeding purposes.

The supplemental report of Professor Cottrell outlines some very extensive plans for investigations in pig feeding, the importance of which I am sure will appeal to your judgment, and I trust will have your earnest consideration and support.

The National Horse Breeding Experiments.—This division of our work is directly in charge of the head of the Agricultural Department, under the United States Department of Agriculture, and I have to report very encouraging progress. Last year five foals were secured from five of the mares that were in foal when purchased. These have developed into strong, thrifty colts, of a size and quality for their age that augurs well for the future success of the experiment. Of the nineteen mares in the stud bred last year, seventeen proved to be in foal, two aborted and one colt died at birth. We now have fourteen fine thrifty colts, all showing marked uniformity of characteristics and all approximately the type desired. The stables and corrals, the building of which was made possible by the special appropriation by our State Legislature two years ago, have been completed at an approximate cost of $6,000, about $4,800 of which came from the special appropriation and the remainder from College funds. As this experiment progresses and the stock multiplies, there will be urgent demands for additional sheds and paddocks. At the present time there is great need for shelter for the brood mares.

Respectfully submitted,

W. L. CARLYLE,
Agriculturist.

REPORT OF AGRONOMIST.

I take pleasure in reporting to you the work of the Agronomy Section of the Experiment Station since December 1, 1905.

Since that time our experimental grounds have been enlarged by the station gaining possession of the land purchased two years ago for experimental purposes. I have never seen better grounds for demonstration experiments than the new Experiment Farm presents. The soil, however, is not in good mechanical condition, and we shall plan our crop work to bring it into better tilth. The work of this section is divided as follows:

1. Co-operative work over the State with good representative farmers. We are testing several crops in this way to determine their adaptability to that particular region.

a. Hardy types of winter wheat in southwest Colorado.

b. Desirable native and cultivated grasses for improving native meadows in various parts of the State.

c. The best milling type of durum wheat in 39 of the 59 counties of the State on non-irrigated lands, to determine areas adapted and to what extent it is drought resistant.

d. High altitude grains with the view of pushing the grain belt 1,000 feet nearer snow line.

e. Vetches for forage in the higher altitudes where other cultivated forage has not been successfully grown.

f. Varieties of corn to determine best type for the few regions which are successfully growing corn.

g. Testing crops best adapted for North Park—a continuation of last year's work. This should be carried on for at least another season.

2. Experiments with Mr. Blinn, station agent at Rocky Ford. The work with Mr. Blinn is the development of desirable seed producing hardy, disease resistant types of alfalfa for the Arkansas Valley region. The work is so interesting and shows such a satisfactory beginning that I wish Mr. Blinn to report specifically upon the progress of this work. I sent seed from various sources and he has done exceptionally well with it.

3. Eperiments at the home station. The following outline gives a summary of our field experiments now under way:

a. Development of a Colorado type of durum wheat, of known milling value, adapted for certain non-irrigated lands.

b. Development of the earliest maturing types of wheat, barley and oats, of reasonably good yielding power and of good quality for the higher altitudes.

c. Development of a barley of high feeding value adapted for the irrigated lands and another type having drought resistant power adapted to certain non-irrigated lands, the object being to substitute barley for corn in finishing certain classes of live stock for market.

d. Development of distinct types of alfalfa well adapted to Western conditions which show disease resistant power, hardiness and carry a high percentage of leaf to stem, increasing forage value. This is so important a work that the alfalfa expert of the Nation—Mr. J. M. Westgate—has joined with me in this work. We have our alfalfa nursery south of Agricultural hall and expect to make this breeding of alfalfa one of the most important divisions of the agronomy work.

e. Development of a malting type of barley adapted to the irrigated lands of the foot hills and mountain mesa regions of Colorado.

f. Development of beardless types of drouth resistant spring and winter wheats of superior milling quality.

g. Experiments to improve cultural methods in beet culture, reduce cost of growing the crop and increase yield and quality of beets.

h. Development of good yielding stock roots well adapted to our climatic conditions. We should grow more roots for our live stock.

4. Correspondence Work. The correspondence work in agronomy has nearly doubled during the year, and I find it takes a considerable portion of my time. I believe this is an important part of the station work that should be carefully and thoroughly done.

5. Publications. During the year our section has issued two station bulletins and two press bulletins.

At the beginning of the year, Mr. A. H. Danielson, the assistant agronomist, left the station work to engage in farming operations for himself, and Mr. Knorr was called to the work. Mr. Knorr had completed his agricultural work under the direct supervision of Prof. W. M. Hays, now Assistant Secretary of Agriculture at Washington. Mr. Knorr was in the junior year of university work in Minnesota and on coming here took up our junior work and completes our regular agricultural course this school year. He is efficient, industrious and careful in his work and is proving a most competent helper in station work.

Respectfully submitted,

W. H. OLIN,
Agronomist.

November 15, 1906.

REPORT OF CROP NURSERY WORK.

The breeding of our field crops to secure increased yields, and plants or grains that are higher in food value than those we now have is one of the many problems that must be worked out by the Experiment Station; the start made at this Station bids fair to success along this line of work; it will be seen, however, that this work is hampered to an extent through the lack of apparatus and funds.

The growth of the nursery and the results obtained this year are as satisfactory as could be expected under the conditions under which we worked. The land on which the nursery was located was in sugar beets the previous year; when the beets were removed the ground was wet; this packed the soil and left it in a poor physical condition; later on the pasturing of the tops by cattle again packed the soil; the scattering of manure by these cattle made the field on the whole very uneven, and in a very poor condition for experimental purposes as in some instances the results are hardly comparable.

In the spring of 1906, 155 nursery stocks of wheat, oats and barley were selected from the more than 500 stocks that were grown in 1905; the selections were based upon yield, and quality of the grain. Of the 155 stocks grown, 104 were wheat; these were again divided into 39 varieties of straight selections, and 65 hybrids. At harvest time 46 of the wheat stocks were discarded; 6 stocks were selected for increase in 1907, among which 4 of them are crosses of common and durum wheat, hence a beardless durum type; from the remaining 52 stocks individual selections were made to be used as mother plants in 1907.

Of the barleys twenty-three selections were made in the spring of 1906; of these fifteen stocks were discarded; some of those that were retained promise to be varieties of exceptional merit.

The oats did remarkably well; of the twenty-eight stocks planted only eleven were discarded; the basis of selection for this grain is yield, quality, ability to stand, and rust resistance.

The work with alfalfa is perhaps as promising as that with the grains; the alfalfa nursery contains twenty-six stocks, most of which are from as many different parts of the globe; the first object is to find which of these are best adapted to Colorado conditions; in the spring of 1907, after ascertaining which of these varieties can best stand the winter, individual plant selections will be made. The breeding work with alfalfa is a fairly new proposition; the problems presented along this line are numerous, but the first of these that require our attention are: increased yield; disease resistance; increased leafiness—most of our pres-

ent varieties of alfalfa yield a higher per cent. of stem than leaf, hence a loss in feeding value.

It is hoped that in the coming year we may be able to extend our breeding work to some of the native grasses and other forage plants. All of this work is very slow and painstaking, but if nothing intervenes we may be able to show some results of plant breeding work in less than two years hence.

Respectfully submitted,

F. KNORR,
Assistant Agronomist.

Fort Collins, Colo., Nov. 13, 1906.

REPORT OF THE ANIMAL HUSBANDMAN.

I herewith submit a report of my work in Animal Husbandry and a statement of plans and needs for the future:

I began September 1st, 1906, and by mutual agreement the Animal Husbandry work was divided—you retaining all work with horses and pure bred stock and assigning to me charge of all lines of feeding. October 1st, you engaged W. H. Riddell, a graduate of this College, Class of 1906, as my Assistant.

I found an experiment under way with steers to test the difference between keeping beef cattle on the range from birth until marketed at three years of age and of feeding them through the winters and running them on the range during the summers. There are good yards and sheds for handling the cattle in this test. With this exception I found no stock nor equipment available for feeding work.

A plan for feeding experiments with hogs was submitted to the Director of the Experiment Station and he stated that all funds under his control were needed for experiments under way and that no money could be spared then for feeding tests. The matter was submitted to the Executive Committee of the Board, and they made an allowance from College funds sufficient to provide for yards for feeding 250 lambs and for sheds, yards and hogs for a feeding test with 100 hogs.

At this date we are feeding 250 lambs to ascertain if it will be profitable to cut alfalfa hay when it is fed to fattening lambs. The lambs were furnished by the Wood Live Stock Co., Spencer, Idaho, who pays us for the gains we put on. The yards and sheds are ready for feeding 100 hogs, the experiments are planned and feeding will be started as soon as the hogs can be purchased at a reasonable price.

The lamb feeders have demonstrated the advantages of this State for producing a high quality of mutton profitably and Colorado feeds and conditions are as well adapted for feeding all other classes of farm animals as for sheep. The Animal Husbandry Department of the Agricultural College should demonstrate this on a commercial scale and when we do so, the work will not only enable stockmen now in the State to increase their profits but it will induce stockmen with capital to come in large numbers to this State to secure the special advantages which Colorado conditions furnish.

I urge that at the earliest possible date equipment for this work be provided as follows:

Sheep. Ten feeding yards with feed boxes and water supply, each yard for 100 head, scales for weighing sheep and feed and storage for grain. This equipment will cost about $900.00 and it

is probable that we can arrange to fatten the sheep and lambs needed for experiments, getting paid by the pound for the gains we put on and not be obliged to have the funds with which to buy the animals.

Our first work in feeding lambs and sheep should be to find methods that will secure greater gains for feed consumed and profitable ways of using a greater proportion of Colorado grown feeds. This should be followed by tests to determine the lines of breeding that will produce the most profitable feeder having a carcass with the greatest proportion of high priced cuts.

Hogs. Eighty-five per cent. of the hogs slaughtered in Colorado are shipped in from Kansas and Nebraska, yet Colorado feeds are particularly adapted for producing pork of the best quality and at less cost than pork is generally produced in the corn belt.

Denmark spent large sums in finding what feed would produce bacon having the choicest flavor and found it to be barley; England pays $18,000,000 a year for barley-fed bacon from Denmark and pays a much higher price per pound for it than for the best grade of American corn-fed bacon. Barley is the surest grain crop grown in Colorado, yielding well under both dry land farming and irrigation, and Colorado feeders have alfalfa and peas to feed with it, both of which produce choice flavor in pork at low cost.

We should demonstrate on a large scale just what these and other Colorado hog feeds will do and induce Colorado stockmen to produce all the pork needed in the State and that demanded both by the high price trade in eastern United States and in Europe.

I recommend the securing of 100 sows and 8 boars, 100 farrowing sheds for individual sows, yards for 100 sows and their pigs, fattening sheds for 500 pigs and the division of 50 acres of land west of the farm machinery sheds into ten five-acre lots for hogs. This plan will cost about $6,500 and by raising two litters a year we can feed and market 1,000 hogs annually.

We should find the best methods and feeds for producing pork cheaply, then in co-operation with the packers determine ways of feeding and curing to produce the choicest flavored products; when we have secured both these, we should send our College fed pork to Europe and find what modifications in feeding and curing will be desirable to fill the requirements of the highest priced trade there.

Poultry. One million and a half dollars worth of poultry were shipped into Colorado the past year and the entire yearly poultry products marketed in the State will not supply Denver alone for more than sixty days.

Few states have as favorable conditions as Colorado for profitable poultry production and the State should not only produce all the poultry and eggs it needs but should ship to other states several million dollars worth annually.

The Agricultural College should take hold of this industry and push it. We should keep 1,000 hens and I recommend 20 colony houses, each for 40 hens, 20 colony houses each for 10 hens, an incubator house for 20 100-egg incubators, brooding facilities for 5,000 chicks and a fattening house.

The building equipment needed to start this work will cost about $2,500 and I believe the poultrymen will aid us with donations of a sufficient number of fowls. With such an equipment we could determine the best methods of breeding, rearing and handling poultry in Colorado and could establish a practical poultry school. This work will interest and benefit financially more people than any other line we can take up.

Beef Cattle. Colorado feeds are particularly adapted for the production of beef on growing animals. We need ten feeding yards with sheds, racks, feed boxes and water supply each for twenty head and I believe the work we should first undertake should be the testing of Colorado feeds in the production of baby beef, taking calves off the range at weaning time and fattening them ready for market when twelve to eighteen months of age.

Dairy Cattle. The best work that we could do at present with dairy cattle would be to take 20 ordinary cows off the range and develop them as quickly as possible a dairy herd of twenty cows that will produce per cow per year 8,000 pounds of milk and 400 pounds of butter.

Respectfully submitted,

H. M. COTTRELL,
Animal Husbandman.

November 7, 1906.

REPORT OF THE VETERINARIAN.

To the Director:

The claim is made, and I believe fully substantiated, that tuberculosis and asthma in the human family are greatly benefited by the climatic conditions found in Colorado. It is also true that not one of the great animal scourges has ever seriously threatened our State, and our live stock is to-day as healthy as can be found anywhere.

These facts are no doubt responsible for the sweeping claim often made and entirely unwarranted that tuberculosis, hog cholera, and other contagious diseases do not find a natural habitat under the climatic conditions found in the arid West. The danger is that we become overzealous in our claims in this respect and relax our vigilance in necessary quarantine and sanitary measures.

As college veterinarian, I am frequently called to various parts of the State to investigate outbreaks of supposedly contagious diseases among all kinds of domesticated animals. This field work is not always directly connected with my duties as veterinarian to the Experiment Station. It serves, however, to keep me in touch with the existing live stock conditions throughout the State, and which is indispensible to my work in every way.

The most important diseases named casually in the order of their economic significance are as follows: Tuberculosis, mostly in cattle and swine; poisonous plants, largely on the open range; mange in cattle in western half of State; strangles in young horses all over the State; scabus in sheep; black leg and anthrax; contagious abortion in cattle; parasite diseases; calf scours; horse typhoid; calf diphtheria; hog cholera and glanders.

Poisonous plants, horse typhoid, and tuberculosis have been the subjects of special investigation since my last report.

LOCO WEED INVESTIGATION.

The investigation of loco weeds has progressed satisfactorily. We were fortunate in securing the same pastures and buildings at Hugo that served us so well last year. In addition to the station at Hugo, the Department of Agriculture saw fit to start another station without our co-operation at Woodland Park, on the Divide.

By mutual agreement it was decided to withhold report on this work until the investigation is completed, or at least far enough advanced to warrant positive assertions. Although a

number of the experiment animals (horses and cattle) at Hugo are badly locoed, there will probably be at least twenty live over until spring.

The work thus far has brought to light some of the hidden mysteries surrounding this perplexing problem, and it is hoped that it will result in something that will be of real economic value to the live stock industry, as well as a valuable contribution to science.

The last part of the work, yet to be done, is of vastly more importance. It is not sufficient to simply know the specific cause of the locoed conditions. The question always to the front is, What are we going to do about it? Unless we are able to suggest effective prophylactic and remedial measures, it will have very little if any economic value.

Bulletin No. 113 on "Larkspur and Other Poisonous Plants" was published early in the summer. This was an illustrated bulletin, gotten out especially for the farmers and stockmen, and containing a summary of what is known about Western poison weeds, with a patent suggestion as to the best means of contending with them.

HORSE TYPHOID.

This disease, it seems, has existed in the State for several years. In the last two years it has greatly increased, and in the vicinity of Colorado Springs and on the Western Slope has caused the death of a large number of horses. It is so entirely unlike any disease known to horsemen and so little understood by veterinarians that the appellation "No named disease" seems quite appropriate. The symptoms are much like typhoid fever in the human. In many respects it is like malarial fever, swamp fever, or the oriental disease, surra. The victims practically all die in from three weeks to as many months.

In Wyoming, where the disease has assumed more serious proportions, investigation revealed the presence of large numbers of parasites (Strongulus armatus) in the large intestines. This led to the assumption that they were in all probability the direct cause of the malady. Our work with the disease thus far has not tended to substantiate this claim. In most cases it is found in horses that graze on bottom lands. In exceptional cases, however, the disease has developed in horses stabled and furnished with apparently pure water. The symptoms all point to the presence of a blood parasite, but so far we have not been able to find it. The etiological factor in this case, as in many others, can only be worked out in the laboratory. Our laboratory equipment is so meager as to make even a satisfactory blood count impossible.

A summary of our work with tuberculosis in the college herd, for the past six years, is as follows:

PER CENT. NATIVE TO COLORADO.

Year	Tested	Responded	Reacted	Per Cent.	Kept Over
1900	9	5	55.5	60	2
1901	27	7	25.8	00	5
[illegible]	36	12	[illegible]	[illegible]	8
1903	50	7	14	14.3	0
[illegible]	29	5	16.4	25	2

Sixty-three and six-tenths per cent of cattle tested were natives of Colorado; 25 per cent of all cattle responding were native Colorado cattle.

Test in 1902 included six animals that reacted in 1901.

Test in 1903 included eight animals that reacted in 1902.

Test in 1906 included no animals that reacted in 1903.

One animal responding still remains on the farm.

Leaving out the animals each year that had previously responded to test, the following results were obtained:

Year	Tested.	Reacted	Per Cent. Reacted
1900	9	5	55.5
1901	27	7	25.8
1902	29	5	10.3
1903	42	0	00
1906	29	5	17.3

This table is especially interesting and instructive as showing that while more than one-half of the cattle tested for tuberculosis were natives to Colorado, yet three-fourths of the animals diseased were imported.

While 11.8 per cent of all native cattle tested on the college farm in the last six years have been proven tuberculous, nearly one-half of all cattle brought from outside the State on to the college farm have responded to the test and were disposed of accordingly.

Respectfully submitted,

GEO. H. GLOVER.

November 13, 1906.

REPORT OF THE ARKANSAS VALLEY FIELD AGENT.

To the Director:

As outlined, the work in the Arkansas valley has been pursued under three general subjects, alfalfa, beets and cantaloupes.

Under the subject of alfalfa, there has been two objects in view: First, the improvement of alfalfa by a systematic seed selection from a nursery of individual plants, and second, the investigation of the methods employed by the most successful alfalfa seed producers to develop the essential conditions that are necessary to a good yield of alfalfa seed under the conditions of irrigation in Colorado.

During the past season our alfalfa seed nursery was enlarged by the addition of twelve rows, sown with seed selected the previous season. A careful observation of the individual plants in the nursery was made and this study revealed the fact that there was a wide variation in individuals which had grown under the same conditions, and that this variation in many instances was in the line of marked improvement, for example, the general yield of seed in the nursery was poor, yet a few individual plants "set" remarkably heavy yields of seed, while many adjacent plants, apparently as vigorous, were almost barren of seed production.

As marked lines of variation were also noted in the matter of desirable hay producing qualities, disease resistance, and possibly the character of the bloom for honey yield. From these desirable variations the seed of sixteen individual plants was saved separately to continue the work in seed selection.

The second topic, the investigation of alfalfa seed production has occupied but little time as yet, but it is the plan during the next two months, while the alfalfa seed threshing is in progress, to visit the most successful seed growers and ascertain their theories and methods relative to alfalfa seed production, and collect as much data as possible for further study, and solve this important question.

Beets.—Under this topic we have continued the efforts to develop a disease-resisting beet. We have now about fifty pounds of seed, the second generation of seed produced since the selection of beets from "curly top"-affected fields in 1903. Since that year the trouble has not appeared in Colorado, and in order to test the merits of our selection at this time, we have sent to Dr. C. O. Townsend, of the Department of Agriculture, about twenty-five pounds of this seed, he agreeing to send it out to portions of California and Utah, where the trouble occurs to some extent

each year, and will report to us if the seed possesses any inherent resistant qualities.

In this connection we have gained considerable knowledge and information relative to the problem of beet seed growing, the methods and conditions required for securing a yield of beet seed; this data might be of value if commercial beet seed growing should be undertaken in the State.

The study of cultural methods for sugar beets, that was outlined, has not been taken up to much extent as yet. It is planned, however, to begin the work during the winter by making a digest, if possible, from the field books of the several beet sugar factory companies.

We have received some encouragement from some of the officials for such a plan of study.

Cantaloupes. This subject has required rather close attention through the summer. The work of developing a rust resisting cantaloupe was continued on a half-acre plat, which for four seasons had produced cantaloupes badly affected with rust, the idea being to develop the quality in as adverse conditions as possible, consequently irrigation was applied in excess to favor the development of the fungus. The plat planted with the seed of nine individual melons planted in rows each one separate, these melons were from the most resistant plants found in 1905.

One row was planted as a check row, with seed from a very perfect melon, but from a field that had not been selected for rust resistance. The plat developed nicely without rust until about August 15; the season was characterized by cool nights and frequent rains and heavy dews, and in July the rust spots appeared on all the early melons, and when the first picking began, about August 10, the fields were getting brown with rust, as was also the check row in the rust resistant plat, while the other rows were comparatively free from rust, some of the rows revealed more rust resistance than others. The seed from the most resistant plants in 1905 were producing this year, also, the most resistant plants.

When the rust had developed to some extent on the plat which was at least ten days later than any field otherwise under equal conditions, the plat was carefully studied, and over one hundred resistant plants were staked with a number, and each day as the ripe melons were gathered they were marked with the number of the hill and the seed saved separately and a description made of the qualities of each melon.

The last of September the numbered hills were gone over and notes taken of their rusted condition, and this revealed that a few of the whole number of resistant plants had remained resistant later than others, and now it is possible to select by the number from several hundred melons, saved separately, the best melons from these most resistant hills, to further develop this valuable trait.

Careful consideration and a great deal of time was devoted to selecting melons with a view to improve their keeping qualities, as well as flavor and all the qualities desirable in a perfect cantaloupe.

The question of the fertilization of the flower and the crossing of varieties was carefully studied.

A comparative test of a list of foreign varieties received from Mr. A. J. Peters, of the Department of Agriculture, was made. Many of this list failed to germinate, but of those that did nothing desirable for home or market use developed.

Some investigational work in regard to the life history of the melon louse and means of combatting the louse were taken up in co-operation and under the direction of Prof. C. P. Gillette.

This constitutes a general review of the work of the season.

The investigation of the development of the cantaloupe industry as outlined has been submitted and published as Bulletin 108.

Yours truly,

PHILO K. BLINN.

November 1, 1906.

REPORT OF THE PLAINS FARM.

To the Director:

I desire to submit the following report for the year 1906, of work done at the Experimental Sub-Station of the Plains.

On September 22, 1905, there was 10½ acres of Turkey red wheat sown on land that was all plowed in the month of May and packed with a sub-surface packer. Eight acres of this land was planted to corn on May 15, the other 2½ acres rested until the wheat was sown, but was worked after each rain, as near the same as the corn as possible, storing the moisture of 1905. On the last day of August the eight acres of corn was cut, yielding 24 bushels to the acre, this land was then disked and harrowed, receiving this much more work than the land that rested. The wheat was sown crosswise of the two pieces, one bushel to the acre, and harrowed three times during the months of April and May; the 2½ acres was cut July 5. While that on the corn ground was not cut until July 10, the piece where the moisture was stored yielded a little over 44 bushels to the acre, while the other piece made 25 bushels to the acre.

There was sown on April 6 five acres of macaroni wheat, which yielded 17 bushels to the acre.

On April 7 there was sown five acres of side oats, sown 34½ pounds to the acre, and cut July 27, yielding 29 bushels to the acre.

There was six acres of corn planted on May 14, which yielded 25 bushels to the acre.

There was some slender wheat grass sown, which gives very fair promise, and a variety of other grasses, of which the Bromis Inermis seems to give the best results.

There was a garden of general character and everything was raised in abundance. The potato crop was unusually good. The trees have done quite well in growth. The cherry crop was good, and plum crop fair. The apple crop was light, the trees were not sprayed, as we had had no occasion to do so heretofore, but this year we were bothered with the worms. The apples blew off very badly and were quite small in size. The peaches have done well, and we had some very fine peaches. The apricot trees were loaded almost to breaking down with fruit, the quality being excellent.

J. B. ROBERTSON,
In Charge.

Cheyenne Wells, Colorado, December 10, 1906.

THE STATE AGRICULTURAL COLLEGE
OF COLORADO

THE TWENTIETH ANNUAL REPORT

OF

The Agricultural Experiment Station

For 1907

State Board of Agriculture.

	Term Expires
Hon. P. F. SHARP, *President*,[1] Denver	1907
Hon. HARLAN THOMAS,[1] Denver	1907
Hon. JAMES L. CHATFIELD, Gypsum	1909
Hon. B. U. DYE, Rocky Ford	1909
Hon. B. F. ROCKAFELLOW, *President,* Canon City	1911
Hon. EUGENE H. GRUBB, Carbondale	1911
Hon. A. A. EDWARDS, Fort Collins	1913
Hon. R. W. CORWIN, Pueblo	1913
Hon. F. E. BROOKS,[2] Colorado Springs	1915
Hon. J. L. BRUSH,[2] Greeley	1915
Governor JESSE F. McDONALD[3]	
Governor HENRY A. BUCHTEL } *ex-officio.*	
President BARTON O. AYLESWORTH }	

EXECUTIVE COMMITTEE IN CHARGE.[4]

P. F. SHARP, *Chairman*

B. F. ROCKAFELLOW. A. A. EDWARDS.

EXECUTIVE COMMITTEE IN CHARGE.[5]

B. F. ROCKAFELLOW, *Chairman.*

A. A. EDWARDS. B. U. DYE.

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[1] Term Expired April 10, 1907.
[2] Term Began April 10, 1907.
[3] Term Expired January 1, 1907
[4] To April 10, 1907.
[5] Since April 10, 1907.

STATION STAFF.

L. G. CARPENTER, M. S., *Director* ----------Irrigation Engineer
C. P. GILLETTE, M. S.,----------Entomologist
W. P. HEADDEN, A. M., Ph. D.,----------Chemist
WENDELL PADDOCK, M. S., ----------Horticulturist
W. L. CARLYLE, M. S.,----------Agriculturist
G. H. GLOVER, M. S., D. V. M.,----------Veterinarian
W. H. OLIN, M. S.,----------Agronomist
R. E. TRIMBLE, B. S., ----------Assistant Irrigation Engineer
F. C. ALFORD, M. S., ----------Assistant Chemist
EARL DOUGLASS, M. S., ----------Assistant Chemist
S. ARTHUR JOHNSON, M. S., ----------Assistant Entomologist
B. O. LONGYEAR, B. S.,----------Assistant Horticulturist
E. B. HOUSE, M. S., ----------Assistant Irrigation Engineer
F. KNORR, B. S., ----------Assistant Agronomist
P. K. BLINN, B. S.------Field Agent, Arkansas Valley, Rocky Ford
E. R. BENNETT, B. S., ----------Potato Investigations

STATE FRUIT INVESTIGATIONS, GRAND JUNCTION.

O. B. WHIPPLE, B. S., ----------Field Horticulturist
E. P. TAYLOR, B. S.,[1] ----------Field Entomologist

OFFICERS.

President BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S., ----------Director
A. M. HAWLEY, ----------Secretary
MARGARET MURRAY, ----------Clerk

[1] Resigned October 15, 1907, to become Entomologist, State Fruit Experiment Station, Mountain Grove, Missouri.

LETTER OF TRANSMITTAL.

To His Excellency, Henry A. Buchtel, Governor of Colorado:

In accordance with the conditions of the act of Congress which requires a full and detailed report of the operations of the Experiment Station, I have the honor to present herewith the Twentieth Annual Report.

The financial statement is for the fiscal year ending June 30; the other portions being reported substantially for the current year.

L. G. CARPENTER,
Director.

FINANCIAL REPORT OF THE COLORADO AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING JUNE 30, 1907.

RECEIPTS.

DR.

From the Treasurer of the United States as per appropriations for the fiscal year ended June 30, 1907. under acts of Congress approved March 2, 1887, (Hatch Fund) and March 16, 1906, (Adams Fund)	Hatch Fund	Adams Fund	State Fund	Special Fund	Totals
	$15,000.00	$7,000.00	.....	.....	.....
Balance on hand July 1, 1906	.....	.....	$2,364.52	.....	.....
Miscellaneous	.....	.....	.....	$7,497.68	.....
Total Receipts					$31,862.20

DISBURSEMENTS.

By Salaries	$ 9,111.27	$4,614.81	$ 843.33	$1,069.96	$15,639.37
Labor	1,200.34	701.55	276.02	695.95	2,873.86
Publications	1,914.26	.....	.....	2,266.47	4,180.73
Postage and Stationery	616.07	93.07	17.60	159.16	885.90
Freight and Express	522.23	108.57	12.50	198.38	841.68
Heat, Light, Water and Power	5.90	.....	.....	16.30	22.20
Chemical Supplies	.....	38.05	.....	12.45	50.50
Seeds, Plants and Sundry Supplies	203.12	23.15	53.54	80.54	360.35
Fertilizers	.....	.....	.....	.....	.....
Feeding Stuffs	11.10	.....	.....	431.86	442.96
Library	1.80	655.26	.....	3.00	660.06
Tools, Implements and Machinery	19.50	.....	17.00	11.00	47.50
Furniture and Fixtures	90.29	28.45	42.25	22.95	183.94
Scientific Apparatus	131.59	228.34	5.20	98.64	463.77
Live Stock	.....	.....	.....	533.30	533.30
Traveling Expenses	704.93	508.75	175.90	500.17	1,889.75
Contingent Expenses	21.00	.....	841.24	227.85	1,090.09
Buildings and Land	446.60	.....	79.94	327.37	853.91
Total Expenditure	$15,000.00	$7,000.00	$2,364.52	$6,655.35	$31,020.20
Balance				842.33	842.33
				$7,497.68	$31,862.20

REPORT OF THE DIRECTOR

To The State Board of Agriculture:

Gentlemen—In this report as Director I will discuss more the general problems of the Station, and those which pertain to the work and policy as a whole, and will attempt to give information which bears upon the general work, and to show what the Station is doing.

The variety of work has had a tendency to increase. Funds from State and other sources have served to extend the work so that more topics need to be discussed than usual. The Station, and in fact all of the Stations of the United States, are at a turning point in their history, are hunting for light, and feeling their way toward their proper function. It was a number of years after the Hatch Act was passed before the Stations as a whole grew to their responsibilities and came to a clear understanding of their proper scope.

With the passage of the Adams bill another period in their life comes, which involves not only the interpretation of the law but also a growth of the idea of important scientific research. It will undoubtedly be a number of years before the Stations will have reached a uniformity of sentiment, and have gotten clear light on many of the problems which this Act brings up. The limitations of the Act are at present troublesome, and cause much preplexity to the Stations, and the feeling among many that the interpretation is arbitrary and unnecessary. The provisions of the Act, however, place the control of the funds much more directly in the hands of the general Government than the Hatch fund. This was probably done because some of the Stations at least, did not live up to their duties as institutions for the advancement of scientific investigation along agricultural lines. Some were affected by itching for popular applause, and some had used money in ways that were at least doubtful. While these restrictions are at present the cause of much perplexity, I have no doubt that in the course of a few years it will be generally realized that they have been wise, and that the Stations could not have become so important without them.

The requirements of the bill are such as I have previously pointed out. The additional appropriation is not really an addition to our resources. The requirements are correspondingly great, and in fact such as to make additional demands on our other funds in order to utilize this fund within the requirements of the law. As a consequence it appears that some difference in the relations between the Colleges and Stations will result in the course of a few years. Under the Hatch Act, as commonly interpreted, scientific investigation was secondary, and the fund was often used to supplement the salary of an instructor, when the requirements of investigation gave way to the requirements of the routine work of teaching. The conditions of the

Adams fund, however, are more strenuous, and it would appear that it will be almost inevitable that with those principally engaged in scientific research, the scientific work will be primary and teaching and other work will become secondary. In the past if there was conflict the investigational work had to give way. Under the conditions of the Adams Act, if the two conflict it would look as though the adjustment would need to be on the other side. In other words the requirements are such that the Government is in a position to insist upon conditions favorable to scientific work. While at present most Stations are not so situated, nor as yet enough money from the Adams fund, to justify such conditions, yet it seems to me that the tendency will inevitably be that way. The Government already urges that there be only a few men supported from this fund, and that those men give the large part of their time to this work. This means a force of professional scientists, and the use of the fund to a few men of high type who give the greater part of their energies to such investigation. It must lessen the amount of teaching which they can do, but the final result will be to put such Institutions more of the type of the German Universities. The transition and development is bound to be slow, and possibly painful, but if I forecast the development rightly, the inevitable and final results will show that it is best for the Institutions and for agricultural science. At the start and for a few years there will be misunderstanding and criticism undoubtedly from failure to understand the wisdom of the law, but the situation of the Government is such that it seems to me the result must come.

So much has been done in the name of Experiment Stations that there is not a clear idea among the public as to the scope of the Stations, or their limitations, and this same vagueness of idea is not free from the staff of the Experiment Station. Popular applause is very often, if not generally, given to the work which is not really scientific, and in fact scientists very generally doubt work so heralded. It was the result of wide experience that physicians reached the conclusion that reputable physicians must not advertise.

The Experiment Stations had at the passage of the Hatch Act relatively few trained men to draw from. With the requirements of the Adams Act there are now not sufficient qualified men to meet the demands of the Stations. They should, to some extent, be trained. The requirements are such as to need the most thorough scientific training as a basis, and it should encourage years of preparaiton. Whether we deceive ourselves or not the final standing of the Stations will be fixed by the opinion of scientific men.

A part of the confusion in the consideration of the scope of the Experiment Stations is because of the fact that there are different sources of support, and a Station may have three very different lines of action. It needs to be considered;

(a) As supported from U. S. Government funds
(b) As supported from State Appropriations
(c) As supported by private and other funds

As maintained by the U. S. Funds, that is the Hatch fund and the Adams fund, its powers and its duties are such as are contained in these two acts of Congress. Some things it is prohibited from doing, some things it can do, and some things it is required to do. Under these limitations extension work is not permitted, except as it may be considered as a form of publication, which is permitted under the Hatch Act. This manifestly would be improper, more than to a very moderate degree, for the Act strictly speaking, refers to publication of results. It is to be anticipated that much that has been permitted hitherto under the Hatch Act will be more strictly inspected by the Government in the future.

The Adams fund cannot be used for printing nor for the organization of the Station. None of this fund can be used for the purchase or rental of lands, nor for the operations of farming, nor can they be used directly or indirectly for the salaries of persons whose work is not in connection with the Experiment Station, nor can this fund be used for permanent substations.

Likewise under the State appropriations the Station would be permitted to do whatever may be permitted by the State Act. Thus the appropriation by the Legislature last winter is such that almost anything can be done under the different sections of the Act that may be thought desirable. It is not subject to the limitations of the National Act. Any investigation tending to develop the animal interests of the State, or of the grain and forage interests, or the fruit interests, would be possible. Substations, extension work, the distribution of seeds, and many other things which were not the purpose of the National Act, would be possible under these provisions.

Likewise under the third class such funds as are given by private subscriptions or from other sources, would be subject to their own limitations. Under this may be such as the Delta County subscription of the past year, the Mesa County subscription of the previous year, funds from cooperation with the Government, in each the funds are available for the special purposes provided for. So likewise may be classed the direct support from the State Board of Agriculture. Its powers are so wide that it would legally be possible for them to give funds for almost any purpose.

Inasmuch as the U .S. Department of Agriculture may, and does, do many things which we cannot do under the Hatch and Adams funds, it is sometimes supposed to be inconsistent. This is not so, for its funds are given by Act of Congress, and as these are given annually, and as the conditions are changed from year to year, it is only limited by these conditions, and in that case the funds given to it bear the same relation as the State appropriation does to us. Hence while we may not support a substation from the U. S. funds, the Department of Agriculture may do so, if the conditions of the grant to them are such as to permit it.

Demonstration work, variety testing, the distribution of seeds, etc., and various cooperative work which are perfectly proper under section B are not proper under section A. So publications which may be

proper under either B or C may likewise not be permissible under the Government funds of the Station. Such bulletins are often printed and such work done. Inasmuch as the distinction concerning the source of the revenue, and the conditions is not made confusion often arises as to the work of the Station. The Cornell Experiment Station has had a large appropriation from the State, and thus does much work from these funds that it could not do from Government funds. The Geneva Station also has a large amount from the State, amounting now to nearly $100,000 per annum, and only under conditions made by the Legislature. Hence such stations are not guides as to the limitations of other stations which are largely restricted by Congressional requirements.

It may be desirable to distinguish in the publications, the work done under these different funds, as a means of educating the public and of preventing this misconception which frequently leads to embarrassment and to dissatisfaction which would not arise if the limitations were understood.

It then follows that the conditions and requirements for the workers in the second class of work may be very different. Demonstration work and the work which brings the Station in contact with the public and attempts to put at their disposal the work of the Station and of the College, is exceedingly desirable, but it is not in itself scientific work, nor is it permitted to more than a moderate degree under the terms of the Government grants. These things need to be supported from the State and other funds. The fact that it is not permitted by the Government acts does not show that these officials do not realize its importance and value, but rather that they believe that local support can be obtained for such work much more readily than for the scientific work which should be its foundation, and without which such work would lose its inspiration and its value.

As mentioned before the provisions of the Adams fund do not make the conditions of the Station easier. It was expected that the State appropriations would ease the Station funds, but unfortunately it has not done so, especially during the past year. The general expenses of the Station tend to increase, and must do so inevitably. As more work is done there should be more bulletins published. There is a great increase in the number on the mailing list, and this means a direct increase in the expense of publication.

The Farmers' Institutes and the extension work of Professor Cottrell, have brought a very large addition to our mailing list, so that the cost, with the increase in the cost of printing and of paper, and the great increase in the size of the edition, more than doubles the cost of a bulletin. The envelopes for sending out one edition to the full mailing list, will in the future cost about $50. The work of mailing and addressing these envelopes is very great, and if done by hand would mean several weeks' work. Our present system of addressing the envelopes, which served its purpose with a small list, is now outgrown, and it means an additional expense for another addressing

machine. Hence all of these conditions due to the growth of the Experiment Station mean cost. At the same time our funds available for these purposes are fixed. Further demands likewise occur, and many greater expenses. All of the miscellaneous demands which are in consequence of the Adams fund, come back and are a charge on the Hatch fund, or other funds. All of this means more clerical work, it means more correspondence, and therefore more help throughout the Station as a whole. These miscellaneous expenses must be borne by the Hatch fund, and yet may be a direct consequence of the Adams fund. Hence, as I have stated before, the consequences of the Adams fund are not a relief to the financial situation of the Station, but rather make it more strenuous. To some extent this is also true with regard to other appropriations given to the Experiment Station for other work.

When other funds are given, as for the fruit investigations and from other State appropriations, they have a tendency to cause additional correspondence and therefore additional bulletins. Therefore, it has seemed to me that the only satisfactory way to treat the other funds is to estimate the incidental expenses, like bulletins, postage and stationery, and make them a charge against those funds. This I have endeavored to do, and hence in estimating the expenses of such an investigation as the Delta County fruit investigation, the Mesa County, or the animal investigations, etc., I have included the printing as an essential part of the expense. Otherwise the Hatch fund would become practically nothing but a printing fund, and the Station proper might thus have nothing to do with the line of experimentation.

The last Legislature passed a bill appropriating $45,000, of which $35,000 is essentially for the Experiment Station, as follows:

$6,000 for Animal Industry.
$4,000 for Plant Industry.
$2,000 for Grain House.
$2,000 for Farm Machinery and Building.
$500 for Animal Diseases.
$8,000 for Fruit Investigations.
$7,500 for Purchase of Lands.
$5,000 for Co-operative Horse Breeding Work (Provided the Government will spend $10,000).

One-half of this amount should be available the fiscal year ending December 1st, and the other half during the next fiscal year. It was expected that this money, or a proportionate part of it, would be available immediately after the Legislature adjourned, and it has been expected to be available almost every month since. As a matter of fact it was not available until late in October, this was after the growing season, and therefore it meant that such work had to be continued at the expense of other funds, or else dropped. It therefore has led to an awkward situation We realized the fact that a suspension of the work would mean the destruction of its value, and it has therefore lead to a tendency to use other funds and continue the work. The effect has therefore been to make the Station chronically hard up during the season, and to

rather strain the interpretation to justify the use of other funds. The Government auditing officers have questioned the desirability of doing this.

During the entire season, therefore, the Station has been constantly in the situation where its funds were very low, and has been forced to hold back bulletins, and refrain from other expenditures which were desirable to make This awkward situation has arisen with almost every State appropriation. The appropriation of four years ago has not been received until now. The appropriation of two years ago was not available until late in the fall, and the present appropriation was available November 1st, and there is still doubt as to whether we shall receive the full amount for the coming year. This makes an exceedingly difficult situation to arrange for. If the appropriation be for a building, then the delay in the payment simply means the delay in starting, and no more serious result is apt to arise. In the case of investigation or all work which has to be continuous, then such a delay means either suspension of the work or the depletion of the other funds. It is manifest that such work cannot be suspended for 10 months, or even one month without practical destruction of all value.

This kind of appropriation is exceedingly difficult to manage in connection with the Experiment Station. It is far better to have a less amount, but one which can be depended upon with certainty, and to be paid promptly. Hence it would be far better could we have a mill tax for such purposes, for if the total amount is less than the other appropriation, even then the work like the fruit investigation and plant investigation could be continuous, and avoid the embarrassment and difficulty which affect us throughout the year.

This same shortage likewise affected the appropriation for Grand Junction.

While there has been much objection to a mill tax on the part of the people of the State, yet this kind of appropriation becomes almost impossible to use successfully, unless it be that the Board is in shape to stand the additional draft for the period of delay, and to run the risk of failure to get any money, and thus lose what has been advanced.

THE LOCO INVESTIGATION.

A co-operative investigation of the loco plant and disease has been carried on with the Department of Agriculture. The first work on this was done byMr. Payne, who was given special instruction to collect information concerning the disease and its distribution through the study, and interviewing stockmen. He outlined a course of work but manifestly it required much more funds to take up than we had available. It also seemed as a consequence of the whole inquiry that the most important point to be attacked was to determine absolutely whether the disease was a consequence of the plant or not. The disease occurs in widly separated localities in different states, and the plant recognized as the cause in one locality does not grow in others where the disease is recognized.

An agreement was entered into whereby the department sent an expert and we furnished animals and arranged for land. Dr. Glover was to represent the station and to be consulted concerning autopsies and various other work. The total cost to us has been about $1200, aside from the time and some traveling expenses. Dr. Marsh has represented the Government. The previous investigations had failed to find any poisonous element in the plant. As a basis for final remedy of the disease, the cause must be absolutely known, and while the popular belief of cattlemen was that the plant was the cause, yet that might be as wrong as the supposition that has existed for thousands of years that the miasma of swamps was the cause of malaria, or contagion was the cause of yellow fever. Hence we urged in the investigation the determination of the cause.

Dr. Marsh took up the question in a different way. Instead of attempting to determine the poisonous principles, he used the plant or extracts and studied their physiological effects upon small animals. He thinks he has determined the cause. We are not conversant with the details of the work as performed by them, for this, as in most cases of so-called co-operation, consists of our putting up the funds for work by the Government men.

A summary of some of the conclusions was given in the report of 1905. We hope that a report may be made upon this soon.

THE PLAINS SITUATION.

At a meeting of the Board in April, a petition was presented, asking for a substation at Akron, and giving a subscription of $3,000. The Government representative, Mr Chilcott, was present at the Board meeting in June The subscription given by the people at Akron seems to have been based upon the statement that committed us, in popular impression, to the establishment of a Station, but such statement was without authorization and tended to cause some friction and embarrasment. I think, however, that the matter now is practically straightened out. The Government has taken over the land which the people of Akron had provided and with the funds subscribed, have started a station at that point, which they can do under Congressional appropriation, though we cannot under the Government funds at our disposal. Were we to continue such work on the Plains, the plant which we already have at Cheyenne Wells could be used to best advantage. Its location, however, did not prove to be so desirable for the Government inasmuch as they already had a station in Kansas not very far from Cheyenne Wells, and therefore they desired to go farther away. There may be some echoes still as a result of this action, but I think that little more is to be expected.

The last Congress passed a bill, giving to the College, for forestry experimental purposes, a tract of 160 acres near Akron. The land which the Government has is adjacent to this tract. Up to the present time, we have not received a deed for the land. The last correspondence had with the Commissioner of the Land Office stated that he

would look up and see whether there were any adverse claims to this land, but since I have not heard from him, it was supposed that it would come in the ordinary course of proceedure of that office. Any title which we obtain, however, is conditional on the use for five years for such purpose. No funds have been available. The opportunity seemed to be good and rather than lose a year of time, it was thought best to spend the amount that would be necessary for plowing a part of the ground. Accordingly a total expense of about $50. was spent in the plowing. The Government asked us to build a fence on the south side between this tract and the Government tract on the south. The condition of our funds did not seem to permit this, and in addition to that, until we had some evidence of title it seemed undesirable to do. A plan has been discussed with Prof. Paddock and also with a representative of the Forestry Bureau at Washington, to whom plans were referred some time in the summer and their help invited. A man from the Bureau recently invited us, and Professor Paddock accompanied him to Akron to look over the ground and to reach some conclusion as to what was best to do. The negotiations with them has not gone further as yet, and to what extent they will be willing to aid in this work is as yet unknown. We hope that they may meet most of the expense, but while we so hope, it is unusual for them to aid financially to any extent. The total cost of carrying on this work is not, therefore, definitely ascertained. It would seem to require about $150 for 1908. In 1909, the tract would need to be fenced and some planting done so that apparently about $300 in 1909, besides fencing the tract on three sides, or a total of about $800 would be needed. Of this amount, in case the government aids, they might give one-half of the maintenance, but probably would pay nothing toward the fencing, so that the expense upon us would be from $700 to $900 in 1909. In 1910 probably $300

These figures are given not as estimates, but as a rough idea of the amount that would probably be required to continue the work. There is a possibility that the Forestry Bureau may act on the idea of forestry plantation there and plant trees on a portion of the land which has been turned over to the department and in that case it is a question whether it would be necessary or desirable to meet this expenditure and continue the work.

For the coming year, this would require then about $150, and this it would seem necessary for the Board to authorize. It is rather of a demonstrative character, does not fit in with the previous work of the Station, and is a doubtful charge on the Hatch fund.

I called attention to the general Plains situation in one of the previous reports. For a number of years we had a man at Cheyenne Wells. The result was negative. When the Government notified us that the Government funds could not be used for such purposes, we assigned Mr. Payne to work as general Field Agent and to note the conditions in a general way. This resulted in a number of bulletins and some were very valuable studies. They showed that there were possibilities

in the Plains as a whole and for individuals on the Plains. The work and the conclusions together with some recent favorable years have been made the basis of booming by some land speculators, and with the result that they have brought in many settlers on the Plains. The problem is there before us in that respect. They do not need investigations whose results are in the future so much as immediate advice as to how to meet the situation that is now before them. The most beneficial way of meeting the whole Plains is very largely, to meet people, to advise them, to learn the experience of those who have been there, and to make it available for those who have settled upon the Plains.

Many have gone upon the Plains with the hope of making farms and of using eastern crops, and eastern methods, and in some cases have risked their all. Many are bound to fail, even under the most favorable conditions. It is therefore a question whether it be possible to provide money which would permit the assignment of a man for that special work. Mr. Payne who has been an excellent man for such purposes, is now in the employment of the United States. Some arrangement might possibly be made, by which he could give some time to such work. In that case it might cost us from $700 to $1000, possibly less. Another course might be to provide a larger number of Institutes for the Plains. This, however, would involve the idea that we are prepared with the information and the experience necessary to give to those people, so that it will direct them right. This is ony partially true and the people who go on the Plains to advise the settlers as to the most hopeful way of meeting the situation, should have an extensive acquaintance, and therefore I think that it would be very desirable to have a man for that special purpose if it could be done. Mr. Payne has already acquired the experience through his connection with us. Since the time he was active, some conditions have changed on the Plains, and especially the situation in regard to the number of settlers. At that time there were relatively few, and a very few settlers coming in. Since then the number has greatly increased, and the need for work is very much greater.

THE FRUIT INVESTIGATIONS.

The Legislature made an appropriation for fruit investigations. This work was started on the solicitation of the people of Mesa County who provided $1,500. The State Board of Agriculture provided for an additional amount and put in last year, 1906, a total of about $4,000. The Legislature appropriated $8,000 for the biennial period. This is at a less rate than was expended last season. Hence we have had to practice economy. Some expenses necessary last year have not been necessary this year. The $4,000 per annum is scarcely enough as the pay of the two men amounts to $3,000. The appropriation for this purpose is treated differently from the appropriation for other purposes inasmuch as the salaries of the two men are taken from this appropriation. In

the case of the appropriation for Animal Industry, for Farm Machinery, and for Plant Industry, and for Farmers' Institutes the salaries of the men are not charged against the appropriation.

The position of Field Agent is one requiring good sense, and tact, as well as a desire to be of service. The work at Grand Junction has been especially satisfactory in this respect under the charge of Mr. Whipple and Mr. Taylor. Mr. Taylor resigned to take effect October 15, he having been appointed to take charge of the Fruit Experiment Station in Missouri. As his successor we have arranged to appoint Mr. George P. Weldon, As the margin is so small he will not begin until the first of February or the first of March. Under the conditions of the State appropriation and the financial limitations, it will doubtless be necessary to modify the plan for next year. Practically all of the work under this appropriation was performed in Mesa County. The bill, however, is general, and related to the fruit industry over the whole State. It will probably seem necessary to do more work during the coming year in some of the other counties, and probably therefore to leave one man at Grand Junction, the other to be placed at Delta. This seems the most feasible arrangement. From the standpoint of most effective work, it is desirable to concentrate the efforts in a limited area. In this case it is a question partly of expediency. I have already discussed the matter with Mr. Hoyt of Grand Junction who was particularly instrumental in the action of the Legislature, and with Mr. Moore, both active leaders. Mr. Hoyt thinks that we will have to do more in order to hold the support of the other fruit centers. Mr. Whipple now stationed at Grand Junction could also give more attention to Garfield and Eagle Counties. A horse and buggy have been provided. This has been the cause of considerable expense and has not been entirely satisfactory. It costs about $17 per month for keep, besides the repairs of the buggy and depreciation. The experience here and at Delta suggests that it may be better to allow an extra sum and have the men furnish their own transportation. A motor bicycle could probably be had for less than a horse and would do a greater amount of work. It would be desirable for the horse or equipment to be kept by the parties.

DELTA FRUIT INVESTIGATIONS.

A Committee from Delta appeared before the Board asking that some work be done in that county, and pledged $700 for that purpose. It was afterwards found that for some reason, some other centers had not been asked to contribute, and therefore there was some feeling of resentment. We have tried to reduce this and think we have succeeded. The total amount paid was $700. This was in addition to the salary for the time being, of Mr. Paull who was paid from the College funds. The work has had some other difficulties of its own. The fund still remaining will pay for the printing that may be necessary.

The general State appropriation also covers Delta County, and in

all probability the people of that County will not feel like subscribing for another season. We, however, ought to do what we can to help that community as above stated. The plan which would seem to be desirable would be to assign one of these two men to Delta as a headquarters, and make Delta and Montrose Counties his counties for work.

The establishing of these outlying centers of work is a matter of some delicacy. It requires men of scientific training who also are tactful and prudent, otherwise unless we could keep very closely in touch there is danger of great difficulties arising. The work has been appreciated but has also given rise to some difficulties and troubles that have been hard to allay. So far as the work consists in teaching the fruit men how to handle their fruit and insects, it would probably be of relatively short duration. The work ought, however, to be continued at one of those centers for a period of at least ten years. After the first few years, I am inclined to think that a change in plan might be desirable, but that will be a matter for future development.

THE POTATO WORK.

Last year there were some funds available for experimental work on potatoes This was put in charge of Mr. Bennett as potato specialist. His salary was taken care of by the Station funds, amounting to $1,500. There is no doubt that this work is of considerable use, something in the way the work of the fruit investigations is of value to Western Colorado.

A field was rented near Greeley, on the farm of one of the best known growers, Mr. Bliss. There will be about revenue enough from potatoes to pay for the cost of the land. The total expense otherwise involved has been about $600, including the cost of the printing. There was no money set aside for this last year, and we have crippled along allowing some from the special fund. For the coming year, I would recommend an appropriation of $750.

HORSE BREEDING WORK.

The cooperative work with the Government on horse breeding has been continued through the year. The outlay on the part of the College and Station in connection with it has been the barn, a considerable land, and other expenses. There is nothing in this office to show what the Government has put into the work. The Board is under obligation to expend the receipt in the work.

Other matters concerning the work of the various departments are mentioned to some extent in their reports. Most of the work of the Experiment Station is a kind of work that does not lend itself to any startling proceeding and is a quiet steady work, hence while there has been considerable important work, and there is now considerable going ahead, most of it comes under the ordinary procedure of the Station and along ordinary plans so that it does not make any particular comment necessary.

There have been printed during the calendar year so far, nine bulletins, besides eighteen press bulletins. The editions now will need to be increased from 8,000 to at least 12,000 to 15,000, doubling the cost. With the increase it may be necessary, or at least desirable for us to do as some other stations have done, and that is to issue a popular or printed edition which will give a summary of results of the bulletin and then send the larger bulletin on request. One of the most important and laborious studies is Bulletin 124, on Colorado Fodders, giving the results of a number of years' work. Such a one will not have any immediate effect, but represents much work directed along a particular line, and its value becomes more apparent as a foundation of subsequent practice. A number of other bulletins are soon to be ready to issue. The state of the funds has made it necessary to hold back bulletins or not to hasten them and hence it is probable that a number will be issued in the near future.

Our printing bill the last fiscal year was larger than usual, but in the years to come, it will probably be nearly as large. The size was partly due to the payment of some of the expenses of Bulletin 100. In some states, the expense of printing is paid out of other funds and is not put in as a charge on the Hatch fund. The work may be done by the State printer and the laws are such that it is paid for by the State. The fact that we have to meet these bills lowers the efficiency of the Hatch fund On the other hand, considerable help is given from College funds in that heating and janitor service is almost entirely at College expense. The other funds make it possible to divide the proportions more easily and during the present fiscal year, several of the men who give a large part of their time to the Station receive one-half or more of their pay from the Government funds.

The financial statement and reports of the various sections form a part of this report.

L. G. CARPENTER,
Director.

Dec. 1907.

BULLETINS ISSUED DURING YEAR OF 1907.

No. 117. The Colorado Potato Industry, by E. R. Bennett.

No. 118. Western Slope Fruit Investigation, 1906. Report of Field Horticulturist, by O. B. Whipple.

No. 119. Western Slope Fruit Investigation, 1906. Report of Field Entomologist, by E. P. Taylor.

No. 120. The Howard Scale, by E. P. Taylor.

No. 121. Alfalfa, Sugar Beets, Cantaloupes, Notes 1906, by P. K. Blinn.

No. 122. Fruit Growers' Associations, by W. Paddock.

No. 123. Some Press Bulletins on the Plains.

No. 124. Colorado Fodders, An Examination into their composition and Comparative Values, by W. P. Headden.

No. 125. Colorado Fodders, A Study of Comparative Values based on Bulletin 124, by W. P. Headden.

PRESS BULLETINS.

No. 29. Cost of Colorado Roads, by E. B. House.

No. 30. The Howard Scale, by E. P. Taylor.

No. 31. The Green Aphis and the Woolly Aphis of the Apple, by C. P. Gillette.

No. 32. The Locust Borer, by C. P. Gillette.

No. 33. Dairy Work for Plains Settlers, by H. M. Cottrell.

No. 34. Acclimated Seeds, Hints for New Settlers in Eastern Colorado, by W. H. Olin.

No. 35. Wind-Breaks and Shelter Belts for the Plains, by B. O. Longyear.

No. 36. Preparation of Seed Bed, Hints for the Plains, by W. H. Olin.

No. 37. Potatoes on the Plains, Suggestions to New Settlers, by E. R. Bennett.

No. 38. Grasshoppers Upon The Plains, by C. P. Gillette.

No. 39. Summer Culture to Conserve Moisture, Hints for Plains Settlers, by W. H. Olin.

No. 40. Seeding Field Peas, by W. H. Olin.

No. 41. Pruning Locust and Catalpa Trees for Timber, by B. O. Longyear.

No. 42. Western Slope Fruit Investigation. Condensed Report of Field Entomologist, Season of 1906, by E. P. Taylor.

No. 43 Western Slope Fruit Investigation. Report of Field Horticulturist, by O. B. Whipple.

No. 44 Spraying for Codling Moth, Some Important Points to be considered, by C. P. Gillette.

No. 45. The Spring Grain-Louse, by C. P. Gillette.

No. 46. Advice to Plains Settlers, by J. E. Payne.

REPORT OF CHEMIST

To the Director:

I herewith present a statement of the work of the Chemical Section during the period elapsing since my last annual report.

The work on our Colorado fodders has been completed and our results presented in Bulletin No. 124, issued in July last.

The work on the Australian saltbush, *Atriplex semibaccata*, and Russian Thistle mentioned in my last annual report, as nearly completed, was prosecuted to the extent of completing the chemical work on the samples of these plants which I had up to that time collected and I gathered my notes for the preparation of a small bulletin on their composition and value. I, at that time, thought that this Australian saltbush had been studied and its coefficients of digestion determined by the California Experiment Station, and probably also under the direction of the Australian authorities, but I was unable to find such data. Inquiry addressed to the Office of Experiment Stations at Washington, D. C., resulted in obtaining the information that no determination of the coefficients of digestion of this plant was known to that office. It, therefore, seemed to me desirable that these data should be definitely established before we presented this plant to the consideration of our people as a forage plant. But to make a single series of digestion experiments meant, in this case, to grow fodder to be fed and to postpone the preparation of the manuscript practically a year or rather more.

The crop has been grown, but owing to a number of untoward happenings, I fear that we may be necessitated to grow still another crop before we can complete the work but I sincerely hope that such may not prove to be the case. In this connection I wish to acknowledge the willing and interested assistance rendered by Mr. Knorr and his student assistant, Mr. Aicher, to whom is due the credit of our having any crop at all.

The reasons for undertaking this study were given in my last report. Originally, I began growing the plant in order to make a study of it, but as I, at that time, about nine years ago, judged it doubtful whether it would ever become a plant of sufficient importance to any section of this State to justify its cultivation as a fodder plant, I permitted other work to take precedence. But I fear as the eastern portion of our State fills up with settlers, occasion may arise when this plant, owing to its tenacity of life and ability to make a fair growth under adverse soil conditions might be a great boon to them. I propose now to return to my original plan of presenting a short study of

the plant which will be of more general interest than a mere presentation of its manner of growth, cultural needs, etc.

There have been times in the eastern portions of our State when any kind of fodder would have been of great service in tiding stock over a period of severe weather but fodder was very scarce and stock perished from lack of it. Perhaps our increased knowledge and improved methods of cultivation may have removed this danger, still I believe that if it can be shown that the Australian saltbush has a reasonable amount of merit, it will commend itself as a forage for this large section greatly to be preferred to the sand grass, Russian thistle or hay made from the silvery saltbush hays which I know that they have had recourse to in order to keep their stock.

I shall include a short study of the Russian thistle but no digestion experiments. This hay is used to some extent in some parts of the State. Its value is doubtful, though some claim that it is good.

I began the collection of alkalies from this State shortly after I became connected with this Station, thinking at that time that there was probably a big basis of fact underlying the then current public notion that it was an important factor and a growing one which promised to become more deleterious to their lands and crops than it was then. I soon became convinced that the evil effects attributed to these salts and the impending danger due to their apparent increase was greatly overestimated, and as but little satisfactory information was being accumulated, I have not prosecuted the study of the subject except as opportune occasions have presented themselves until within the last year. There are some questions of interest and prossibly of importance in connection with this question, particularly as it relates to drainage, and the use of water carrying considerable quantities of these salts for the purpose of irrigating crops. Again, some lands in our irrigated sections are becoming seeped and pari passu alkalized and it is a question whether the latter effect intensifies the former or not, and further whether the correction of the former will of itself remove the effects of the latter.

During the present season, I have turned my attention quite exclusively to the study of this subject—to some extent in the neighborhood of Fort Collins and Greeley, but to a greater extent in the San Luis Valley, and in the neighborhood of Delta and Grand Junction. Some of the results of this study will have some scientific interest, others will have quite an important economic bearing.

I proposed to take up the study of the water of the Rio Grande del Norte with the intention of studying the changes in its mineral content and their variation in composition as effected by the irrigation of the surrounding lands. I proceeded to the town of Creede with my assistant, Mr. Douglass, intending to begin the study of the water above the point where the Willow Creek joins the Rio Grande. We found the river unusually high and devoted ourselves to the study of the questions pertaining to the seepage and alkali, hoping that the

river in the meantime would fall to its usual stage at this season of the year. Our work consumed over three weeks but the river had not fallen, due to the succession of showers in the mountains and also in the valley. Determinations of the mineral matters in the river water near Creede and three weeks later at Alamosa showed a difference of only abuot two grains per gallon. This result showed that it would be futile for us to prosecute this work under these conditions with any hope of obtaining results which would certainly represent normal conditions. Data which I have already collected relative to the changes in the Rio Grande waters indicate that they are much less than in our northern streams, but I believe them to be normally much greater than indicated by the determinations alluded to and I therefore did not venture to prosecute the work.

I have, up to the present, found no opportunity to approach the subject of mountain or meadow irrigation and a study of the composition of the fodders produced. I furthermore, do not see how I can possibly begin this work for some time to come as the already accumulated analytical work is very considerable.

Mr. Alford has revised the manuscript presenting the results of his experiments with beeswax.

The work on the loss and deterioration of barnyard manure under our conditions came to an abrupt end by the interference of Mr. Montgomery, who needing a load of manure, appropriated ours, utterly spoiling the lot for our further use. Mr. Douglass is preparing an account of the work done. The record covers a period of four years, but only the weights for three years can be used. This interference is very much to be regretted as it rendered our fourth year's work of little value. In the beginning it was intended to study the bacteriology of the pile, but this feature has had to be dispensed with, so our results will present only the loss and changes in its chemical composition. Mr. Douglass will not be able to work consecutivaly upon his manuscript and its preparation will necessarily be slow. It will not be ready before the late summer or more probably the fall of 1908.

It now seems probable that the next bulletin which I will present will be on the Australian saltbush, *A. semibaccata*, and the Russian Thistle, followed by one on the alkalies of Colorado which will include a study relative to use of seepage water for purposes of irrigation.

The analytical work still to be done on these subjects will not permit me to even suggest how soon or how long it may be before I can present them for publication.

So far as our present work is concerned, we need nothing of sufficient importance to deserve mention in an annual report.

The requests for analytical work of a miscellaneous sort, largely waters and soils, continue to be numerous. It is clearly out of the question, with our present force, to do any of this kind of work especially in cases where the request is made by an individual, and where the work can in no reasonable way be made to serve any purpose for the Station. This Section is always ready and willing to give such

information as may be at its command but I have accepted very little of this class of work. I may add further that I would be unable to give the specific information requested in almost all of the cases even if I should have the soils or water analyzed, and in no case which I now recall would any scientific purpose be served.

Respectfully submitted,

WM. P. HEADDEN,
Chemist.

Fort Collins, Colo., Dec. 1, 1907.

REPORT OF ENTOMOLOGIST

To the Director:

I have the honor to present the following report of progress in entomological work supported by the Hatch fund for the year 1907.

During the year bulletins 119, "Report of Field Entomologist of Western Slope Fruit Investigations" and 120, "The Howard Scale," both by E. P. Taylor, and press bulletins, 31, "Green Aphis and Woolly Aphis of the Apple;" 32, "The Locust Borer;" 44, "Spraying for the Codling Moth;" and 45, "The Spring Grain Louse" have been published. A technical paper upon plant lice entitled "Chermes of Colorado Conifers" has been published in the Philadelphia Academy of Sciences, a similar paper describing a new louse upon cottonwood is about to appear in Entomological News, and descriptions of several new species of plant lice (Aphididae) that have been discovered in the prosecution of our work with this group of insects have been sent to the Canadian Entomologist for publication along with life history notes of the species. While the more technical papers have been sent to technical journals, the economic deductions from these studies will be given to the farmers and fruit growers from time to time in Station bulletins.

SOME OF THE MORE IMPORTANT INSECTS OF THE YEAR.

The very mild winter of 1906-7 permitted many plant lice to survive the cold and start their spring broods in unusually large numbers. As a consequence the spring Grain-Louse, *Toxoptera graminum*, was destructively abundant in many grain fields in eastern Colorado, and the woolly aphis of the apple trees was extremely abundant early in the season and, where it was not destroyed by sprays or overcome by its natural enemies it remained a serious pest throughout the season. In regard to the latter pest I am glad to say that our experiments carried on chiefly on the Western Slope, as well as the experience of many orchardists, has proven that kerosene emulsions or tobacco preparations can be used very effectively to destroy this louse upon the trees. The plant lice have become such serious pests in the State that it has been thought best to give them special attention and many species have been collected and observations recorded upon life habits and food plants during the year. This work will be a valuable supplement to the plant louse investigations carried on under the Adams fund.

The Spotted lister Beetle, *Epicauta maculata*, was sent to the

station this past summer from the eastern part of Arapahoe county as a serious pest in potato fields. Arsenical poisons were recommended and Mr. E. G. Sanderson reported very good results from the use of Paris green as a spray.

The Western Wheat Stem Maggot, *Pegomyia cercalis*, which the writer reported in 1904 (Bulletin 94, Colo. Experiment Station) as destructive to a field of wheat near Fort Collins was sent to the station from Littleton and from Cortez as a wheat enemy the past spring during the month of April. This is doubtless a native insect as it seems not to be known outside the state.

The Onion Thrips, *Thrips tabaci*, occasioned considerable loss to onion growers, especially in the vicinity of Greeley, during the latter part of the summer and an effort was made to assist them in finding a practical remedy, Mr. S. A. Johnson making two trips to the district for that purpose.

Mr. D. B. Thurston, horticultural inspector for Boulder county, sent the station specimens of the peach borer, *Sannanoidea exitiosa*, which he reported very destructive to plum, apricot and cherry trees in the vicinity of Boulder. Mr. L. C. Bragg was sent to investigate the conditions and he found this borer quite abundant and actually killing many small cherry trees.

An experimental orchard of nearly 1,000 trees was set in the spring for plant louse experiments chiefly. The entomological garden has been in charge of Mr. Johnson who has found it a very favorable place to study garden pests., his chief attention having been given to the spotted bean beetle, *Epilachna corrupta*, and the potato Flea Beetle, *Epitrix cucumeris*.

The black peach aphis, *Aphis persicae-niger*, has been known to exist upon very few trees only upon the Western Slope for two or three years, but during last spring and the early summer Mr. E. P. Taylor of the Western Slope Fruit Investigations found this louse in many orchards in the Grand Valley and in a few in Delta county. While for a time the lice became quite abundant early in the season they soon dissapeared and did not seem to do much serious harm.

WESTERN SLOPE WORK.

Mr. E. P. Taylor of the Western Slope Fruit Investigations has devoted his attention especially to the control of the wooly aphis, (*Schizoneura lanigera*) and the green apple aphis, (*Aphis mali*) but he has also sent in much important information concerning other insect pests in Western Colorado. His very complete and detailed repot is appended hereto.*

There were two general heads under which research work was taken up, one a biological and taxinomic study of Colorado Aphididae (plant lice), and the other a biological and economic study of the potato flea beetle, (*Epitrix cucumeris* Harr.) The latter study has

* The report of Mr. Taylor details observations made during the year. Being too long to print, it is put on file in the records of the Experiment Station.

been entirely in charge of Mr. S. Arthur Johnson while the former has been in charge of the writer with the assistance of Mr. L. C. Bragg and the department artist, Miss M. A. Palmer. Mr. E. P. Taylor, Field Entomologist for the Western Slope Fruit Investigations, has also collected and made field notes upon numerous species for me.

The three species selected for special study are the Wolly Aphis of the Apple (*Schizoneura lanigera*), the Green Aphis of the Apple (*Aphis mali*), and the Melon Louse (*Aphis Gossvoii*).

As a necessary basis for this work we have endeavored the past year to determine as fully as possible, the food plants of all our common species, and the time of the year when the different species may be found upon their various food plants, and to make careful descriptions of the living lice in their various stages of development. This has required a large amount of field and breeding cage as well as taxonomic work. In connection with the descriptive work the department artist has made careful detailed drawings in color of the lice in their different forms and stages of development.

A few technical papers resulting from the above studies have been sent to scientific journals for publication and others are in preparation. The economic deductions will appear in station bulletins.

The assistance rendered Mr L. C. Bragg and Miss M. A. Palmer in the plant louse work has been most important and efficient.

The work of Mr. Johnson upon the potato flea-beetle will be written up for publication as a station bulletin soon.

The new insectary just being completed will be a great assistance in carrying on future work with these insects.

I am appending an invoice of the property held by this Section that has been purchased by money from the Adams fund.

All of which is very respectfully submitted.

C. P. GILLETTE,
Entomologist.

REPORT OF THE HORTICULTURIST AND BOTANIST

To the Director:

The report of the horticultural section will consist mainly of the sub-reports from the men who have had charge of special lines of work.

The schedule submitted to you at the beginning of the year has been adhered to closely though but little has been acomplished with some of the lines of work; namely, those with which I personally had to do. The reason for this is that the growth of the section both in the college and station requires a great deal of attention as to details. This is particularly true in the extension work which the college is now carrying on.

The experiments with alfalfa blight have not progressed except that we succeeded in securing about thirty strains of seed from the Department of Agriculture and planted them in an infected field. The seeds came up promptly and the plants have made an excellent growth.

The work with tomato blight has been carried far enough to show pretty conclusively that instead of being a new disease, the trouble is due to attacks of a species of Fusarium. This is probably the same species which has been common for several years in various portions of the United States.

The root disease of raspberries has not been worked upon because of lack of time.

The field work in horticulture on the Western Slope continues to be one of our most practical lines. This feature was broadened this year by stationing Professor Paull in Delta county for the season. That there is an increasing demand for this class of help and that much good may be accomplished by it is clearly shown in his report. We hope that this experience may result in placing a man permenantly in that locality.

The potato investigations are now well under way and the problems are developing to such an extent that one man can scarcely keep abreast of them. The experiments now being carried on give promise of valuable results.

Our experiments in forestry have been confined to the tree plantations which have been noted in former reports. The subject of forestry is one of such vital importance that means should be provided so that a man could devote his entire time to these problems.

Respectfully submitted,

W. PADDOCK,

Horticulturist and Botanist.

Fort Collins, Colorado,
December 1, 1907.

REPORT OF ASSISTANT BOTANIST.

During the summer just past my time has been chiefly devoted to the inspection of the cooperative tree planting experiments in my charge, which were inaugurated during the spring of 1906. These experiments consisted in supplying farmers and land owners in various localities with two species of trees to be planted and cared for under the direction of the experiment station. Black locust and the hardy or Western catalpa were selected on account of their general utility qualities, and so far as possible, 300 trees of each kind were sent to one person.

The data secured from these experiments should enable us to make recommendations concerning these trees for planting under most of the conditions occurring in our state. And while it is yet too early to estimate the reliability of the trees under all circumstances still the prospect is in most cases encouraging.

Out of the twenty localities visited fifteen were favorable for the growing of the black locust. The catalpa was not sent to all of these places but made a fair comparative showing in most localities where planted.

In the majority of cases the black locust made the stronger growth and showed somewhat greater hardiness than the catalpa.

Remarkably strong growths of the former were noted in some places where the trees had been given good soil and care.

In a number of cases due to lack of care or poor location the trees failed when the climatic conditions were evidently not unfavorable to their growth. And it was often a source of surprise to see how tenaceous these trees were under the trying conditions in which they were sometimes found.

It may be safely stated from the observations made, that with reasonable care in planting and watering these two species of trees should succeed in situations similar to those in the region of Denver while the black locust is doing well at elevations considerably higher.

Nearly three weeks were spent in the study of our native forest trees in the Long's Peak region. Photographs and data were secured toward the publication of a bulletin on the cone bearing trees which constitute the native timber supply and the forest trees of our forest reserves in this state.

Respectfully submitted,

B. O. LONGYEAR,

Fort Collins, Colo.
Dec. 1, 1907.

REPORT OF POTATO INVESTIGATIONS.

The potato investigation work is being carried on along practically the same lines as last year. The aim of the work is as follows: First; to improve the industry by a study of the best methods of culture of potatoes for this state. Second, to improve the quality and yield of the present varieties by selection. Third, a test of the standard varieties to find if possible a variety that will be resistant to the soil diseases that cause the losses of the potato crop of this state. Fourth, to study systematically the diseases of potatoes of this region. Fifth, to bring this knowledge to the growers by means of publications and lectures or talks with individuals.

Owing to the nature of the work all these objective points are taken up together.

NEED OF THE WORK.

The yield of potatoes of Colorado is from six to eight million bushels per year as against three hundred million for the United States.

The markets for the Colorado potatoes extend over more than half of the United States. The soil and climatic conditions of a large part of Colorado are such that when no disease prevails no part of the United States, except possibly Northern Maine, can produce potatoes of such quality or a better yield. Some localities in the state produce from four to six hundred bushels per acre, yet there are so many failures or partial failures in the crop that the average yield per acre for the state (Bureau of Statistics, U. S. Department of Agriculture) is less than one hundred bushels, or fifty sacks. A general survey of the state shows that there is available land that is adapted to the best potato growing to produce five or six times as many potatoes as it now produces.

The work of selection is being carried on by this writer in several parts of the state and also in cooperation with some of the best growers in several districts.

One and fifty-five hundredths acres of land were rented on the E. R. Bliss ranch at Greeley on which were planted seventy-six varieties and a quantity of seedlings. Among the varieties were some of the standard French, German, Russian and Scotch market varieties, also some alcohol potatoes from Germany. A large number of these varieties made good yields and crates of each have been selected for use next season. Almost no disease appeared in these plots so no data could be taken as to the disease resistance of the different varieties.

A plot of about one acre of potatoes was planted on the college farm for the purpose of studying diseases and the effects of different methods of cultivation and seed treatment.

Only one variety was used on this plot. The seed was divided and part cut while the remainder was planted whole. The cut seed was divided and treated respectively with dry sulphur, air slaked lime, dry Bordeaux, and a part left untreated.

DISEASES OF POTATOES.

Potatoes have been less troubled by the fungus diseases this past season than the year previous.

Fusarium:—Soon after planting this season a rot developed in the pieces of seed potatoes. The rot started on the cut surface of the seed and worked through to the skin. Some rotted so quickly that the sprouts did not start at all. Others rotted more slowly so that the sprouts emerged from the ground but soon died because of the rot following up the stem from the seed. An examination of these stems and rotting tubers showed the presence of a fungus which is supposed to be Fusarium solani.

A poor stand resulted from this disease, especially on land that had been in potatoes the previous year. Microscopical examination of plants were made at intervals all summer but while the fungus could be found during the whole season, little damage was done by it during the latter part of the season except in a few localities.

Comparatively little is known of this disease at present. Work on it is being done and will be continued during the winter in the greenhouse and laboratory.

Rhizoctonia:—The Rhizoctonia, or stem and root rust disease, did much less damage in the state than in previous years. Places where the soil was hard and compact or basins where water settled were the only places troubled seriously by this fungus.

Work with this disease is going on in the laboratory and greenhouse. Potatoes grown in the greenhouse under sterile conditions and inoculated with Rhizoctonia produced scabby potatoes as well as the Sclerocia or resting stage of the fungus.

The subject of scab from other sources is being also studied. German botanists claim that scab on potatoes may be caused by several different fungi. Cultures of the fungus that is supposed to cause the scab of the eastern states have been obtained and will be used to inoculate growing potatoes in the greenhouse this winter.

EXTENSION WORK.

Considerable time has been spent during the past season in investigating the conditions and talking at institutes in different parts of the State. In the opinion of the writer this work is desirable, especially in the newer parts of the State, where the knowledge of cultural methods and varieties best adapted to the conditions is limited.

Respectfully submitted,

E. R. BENNETT.

Fort Collins, Colo.,
Dec. 1, 1907.

WESTERN SLOPE FRUIT INVESTIGATIONS.

Report of Field Horticulturist.

The work of the field horticulturist during the past year has been along the lines suggested in my report for 1906. Practically all of my time has been devoted to Mesa County. Investigations of plant diseases, cultural methods, handling irrigation water, pruning and the collection of data on the fruit industry in Mesa County has largely occupied my time.

In the work we still have the hearty cooperation of the fruit growers. Requests for information have been more numerous and orchards and vineyards have been freely placed at our disposal for experimental purposes. The work is beginning to show more definite results as time passes.

The orchard survey work has progressed during the year as time would permit. The county has not been covered by any means, but other work of more immediate importance seems to require the time that should be devoted to this work.

The plant diseases under observation have been largely those mentioned in my last report. Very few new troubles have appeared although some of the diseases found last year have apparently assumed more importance.

The loss of grapes from the attacks of powdery mildew called for experimental work in the control of this disease. Experiments were outlined in the use of Bordeaux mixture and powdered sulfur in this fungus. Results of these experiments and observations in other vineyards show that the fungus is most easily controlled by the use of sulfur. Two dustings, one just as growth is starting and one after the fruit has set, seem to be sufficient.

Peach mildew again appeared in a few orchards and presented the opportunity for demonstration work in the control of this fungus. Experiments undertaken in a badly infected orchard only go to prove more conclusively that such an orchard can be thoroughly cleaned up with one careful spraying with half strength Bordeaux mixture.

Pear blight has caused some serious loss and many neglected orchards are practically gone. It has also caused much anxiety by attacking some apparently well cared for orchards.

The root rots are seemingly gaining some headway in the destruction of some varieties of apples. An effort was made to show the effectiveness of treating affected trees by cutting away the diseased bark, and washing the wound with a disinfectant. The results of

this work were very discouraging, and in fact almost demonstrated that such a practice means only failure. The use of lime about the base of the tree, as a preventative measure, was also tried and seems worthy of a more thorough test.

Some other plant diseases of minor importance found during the year are powdery mildew of the apple, powdery mildew of the squash and cantaloupe and the Fusarium wilt of the cantaloupe.

Some experiments were undertaken in cross pollenation of apples but on account of many of the blossoms being lost by the frost this work will hardly give any reliable results.

It is gratifying to note that the growers are heeding the instructions of the Experiment Station staff in the more careful use of water and the handling of various types of orchard soils.

Respectfully submitted,

O. B. WHIPPLE,

Grand Junction, Colo.,
Nov. 1, 1907.

REPORT OF THE DELTA COUNTY FRUIT INVESTIGATION.

April 24 to September 5, 1907.

At the request of a committee of fruit growers from Delta County, was assigned to this work which was prosecuted between the above ates.

The nature of the work was primarily two-fold; first, so far as ossible, to give advice and aid to the fruit growers upon any line n connection with their work; second, to collect information on all natters pertaining to horticultural interests.

To the people of the County the success of the investigation is neasured entirely by the results obtained under the first class; because f its fundamental and lasting character, forms the superior basis for udging of the value of such work. However, in this class the obser- ations of one season are of but slight value of and by themselves, ut must be repeated through successive seasons to test their accuracy nd finality. It is because the practical fruit grower or farmer judges hings mainly by immediate results, whereas the horticulturist foresees hat the basis of correct practices lie in the slow and laborious collec- ion of data from observation and experiment, that both of these lines f work are essential in such an investigation.

The work naturally divided itself into several lines in each of hese classes, in fact, in most cases being common to both.

A discussion of a few of the problems attacked follows:

ENTOMOLOGICAL WORK.

The most of my efforts along this line were directed to the carry- ng out of a series of spraying experiments against the Green and the Woolly Aphis of the apple, by far the most serious insect pests of the ear. One large grower offered to place at my disposal his orchard nd to furnish labor and materials if I would direct the experiments: Comparative tests of many different sprays and combinations resulted n determining that a strong tobacco extract, applied with or without oap, at a high pressure, in proportions from 1 to 80 to 1 to 65 was y far the most efficient summer spray for these pests and that they nay be very well controlled by this method.

SMUDGING AS A MEANS OF FROST PROTECTION.

Here, as elsewhere in the State, there occurred great losses to the fruit crop by successive freezes in April and early May. Following he example of the Grand Valley some attempts were made to smudge, sing baled hay. Believing this to be too expensive a material for the

amount of smoke obtained, I set about finding a material which should combine ease of handling and storage, maximum smoke-producing power and low cost. This was secured in a compound of sawdust, gas-tar and crude oil, in which the sawdust forms the base, the gas-tar a binding material, and both gas-tar and oil throw thick black smoke. It is believed that this can be made at about one-half the cost of the hay, and moulded into blocks by hydraulic pressure for ease in handling and storing. In an actual orchard test upon one acre the temperature was raised from 5 to 7 degrees in different parts of the area. This would have saved the crop in the spring. There is a likelihood of a company being formed to manufacture this material in the County.

SOIL AND DRAINAGE PROBLEMS.

These problems are unique in this County and little understood. The few drainage systems thus far installed are not very satisfactory. Believing that great value would result from a soil survey, I placed in circulation a petition to the U. S. Bureau of Soils and secured more than 200 signers among the property owners in various parts of the County. This is on the way to Washington, and it is hoped will result in a thorough survey at an early date. I also succeeded in interesting the Division of Drainage and Irrigation Investigations of the Office of Experiment Stations, U. S. Department of Agriculture, in the problem of drainage, and they sent an engineer who spent about a week looking over the ground. As a result they will later on locate an engineer in the County to conduct cooperative drainage experiments with the farmers and fruit growers there.

Considerable advice was given concerning methods of control of plant diseases, the use of water in the orchard, cover crops, etc., which seemed to meet with general approval. Altogether it appears that the work of the season was valuable far beyond its cost and if possible should be continued.

Respectfully submitted,

L. F. PAULL,

Dec. 1, 1907.

REPORT OF AGRICULTURIST

To the Director:

I take pleasure in submitting herewith brief reports from the animal husbandry, farm mechanics, agronomy and horse breeding divisions of the Agricultural Department of the Experiment Station.

I regret very much that the work that we have been enabled to accomplish for the past season has been so unsatisfactory and so limited in extent in this Department. The reason for this condition may be found, however, in the fact that the funds provided for research work in this Department are practically all obtained from special state appropriations. These appropriations as made by the last legislature were liberal and had they been made available early in the year when we expected they would be, we should have had a very much different report to make. As it was, however, we had no funds other than those that were advanced by you from other funds from time to time to carry on absolutely necessary work until the month of October of this year, when the state appropriation funds were turned over. Consequently no experiment work whatever was undertaken in the animal husbandry division other than to carry over some steers on pasturage. The work in the agronomy division was curtailed and limited owing to the uncertainty of our funds being adequate to carry on any extended lines.

In the farm mechanics division we were also compelled to lie perfectly idle during the summer months because of no funds being available.

We earnestly hope that some provision may be made in some way for the future whereby we can have some funds set aside definitely for these different divisions, that may be made available early in the year. Our appropriations as now made, are for the biennial period and as I understand it, cannot be used after the close of the said period except in small amounts. Consequently, all or nearly all of the state appropriations must be utilized in one year of the biennial period. Nearly all of our research work, in order to be of real merit, must be continued from year to year without interruption.

I understand that eighty per cent of the first part of the appropriations made for the biennial period is now available. It will be useful for the feeding experiments in animal husbandry work this winter, but comes too late, however, to be of any especial service for the agronomy and farm mechanics divisions.

The accompanying report of the animal husbandry division outlines the feeding experiments proposed and now under way for the coming winter.

The work carried on last winter was not sufficiently conclusive to warrant us in publishing the results. Consequently they have been witheld for further verification during the coming winter. I take this opportunity, however, to present a summary of the data obtained from the hog feeding experiment conducted last winter. This will be fully elaborated and published early in the coming year together with that from the experiment along similar lines that is now under way.

EXPERIMENT WITH 100 PIGS IN 10 LOTS OF 10 PIGS EACH FOR 102 DAYS, FEBRUARY 2 TO MAY 15, 1907. ALL GRAIN ESTIMATED AT 80 CENTS PER CWT. ALFALFA AND BEETS AT $5.00 PER TON. TANKAGE $30 PER TON.

Lot	Kind of Feed	Total Amount of Feed	Total Gain, 10 Pigs	Average Daily Feed	Ave. Gain per Pig per Day	Amt. Feed for 100 lbs Gain	Total Cost of Feed	Cost, 100 lbs Gain	Profit, 10 Pigs
1	Barley	6083		5.96	1.23	4.86			
	Alfalfa	918	1251	.9		.73	$50.95	$4.07	$30.36
2	Corn	6557		6.42		4.62			
	Alfalfa	998	1358	.97	1.33	.73	54.95	4.04	33.32
3	Barley	3347							
	Corn	3347		6.36		4.28			
	Alfalfa	998	1514	.97	1.49	.65	54.45	3.59	43.96
4	Barley	3110							
	Wheat	3110	1378	6.09	1.35	4.51	49.76	3.61	39.81
5	Barley	3133							
	Peas	3133	1382	6.15	1.36	4.52	50.02	3.61	39.90
6	Barley	3129	1399						
	Shorts	3129		6.13	1.37	4.47	50.06	3.56	40.87
7	Barley	6065							
	Tankage	718	1552	6.65	1.52	4.37	59.29	3.82	41.59
8	Corn	6345							
	Tankage	718	1686	6.92	1.65	4.18	61.35	3.65	48.06
9	Barley	5199				4.61			
	Beets	5348	1127	5.09	1.1	4.75	54.95	4.87	18.31
10	Corn	5354		5.24		5.42			
	Beets	5348	987	5.24	.97	5.42	56.20	5.7	7.95

The report from the agronomy division herewith submitted, outlines a very extensive series of investigations that we have undertaken in a tentative sort of a way, though they have never been definitely approved, nor has any portion of the Adams fund been set aside, so far as I know, for their conduct. We have been very loath to undertake

some of these lines while basing our hope for future support entirely upon the state legislature. If these lines of research are undertaken we should have the assurance that they are to be carried through for a period of years without interruption. Otherwise, there would be no use in beginning them.

The work undertaken has been very carefully followed out by Professor Olin and his assistant, Mr. Knorr. Their report very briefly outlines the work accomplished.

HORSE BREEDING.

In the horse breeding division, there has been a steady progress made in the investigations and demonstration work. A number of valuable animals have been contributed to the breeding stud by friends interested in the work. One of the most valuable of these has been received from Ex-Governor Alva Adams. The terms on which this animal was received from Mr. Adams were that the first foal from this mare by Carmon is to be returned to Mr. Adams at weaning time without expense to him. After that, the ownership of the mare is to be ours unconditionally as well as all future produce. Another valuable animal has been donated by Mr. John Kuykendall, of Denver. This mare had a young colt at foot when received, in which Mr. Kuykendall wishes to retain one-half interest. This mare was bred to the stallion Emigrant, owned by Mr. G. W. Rainsford, of Diamond, Wyoming. We were very fortunate in having her bred to this stallion, as he is now 24 years old, and, as he has sired several of our best brood mares, we are hoping that we may succeed in receiving a good foal from him by the mare donated to us by Mr. Kuykendall.

During the year, two additional mares have been added to the stud by the Department of Agriculture through purchase. One of them is a particularly good one and the other fair, though exceptionally well bred. A number of mares did not prove in foal and several of them were very late in dropping their foals. Consequently, we have but 17 foals for the year 1907. With one or two exceptions, these are all very promising.

The foals from the year 1906 have developed into exceptionally promising yearlings. Of the six stallion foals, of last year, four were castrated early in the spring, as they were not deemed of sufficient promise to preserve for breeding purposes. The two remaining ones are very promising indeed as future stallions for breeding purposes. The eight mares with two or three exceptions are good individuals and will be a great addition to our stock of brood mares in the experiment. I feel very confident that the results of our work in fixing the type of an American carriage horse is going to fully equal our expectations. One of the greatest problems in this work is now in a fair way of being successfully solved, viz., that the type we have selected may be perpetuated in the offspring. This seems to have been fairly effectually demonstrated in the two crops of colts now on the College farm.

THE NEEDS FOR THE FUTURE DEVELOPMENT OF THE HORSE BREEDING WORK.

The last state legislature made an appropriation of $5,000 for the conduct of this experiment. Of this amount, $1,000 has been utilized in the purchase of additional pasture land. It will require $2,000 of the remaining portion for the construction of shelter for the brood mares and the young stock. Also in the construction of suitable fences about the small fields and corrals that are very much needed at the present time. We are planning to locate one of these sheds out in the foothills pasture where the mares will have abundance of exercise during the winter months and where they can be fed a certain amount of hay in this shed when it is desired. The other shed will be constructed on the farm adjacent to the present horse stables and will be utilized for the shelter of the young stock and possibly some of the brood mares when it is necessary to keep them where they can be more closely supervised than when in the foothills pasture.

It is hoped that the Agricultural Department will soon add a few choice mares and an additional stallion to the stud. These are very much desired, particularly the stallion, as a number of Carmon's female colts will soon have to be bred and a suitable horse should be obtained with which to breed them. Three or four of the present stock of brood mares have not proven to possess any great merit as breeders and they should be disposed of while it can be done to advantage. It is our plan at present to take the young stock that we do not believe is desirable to keep in the experiment and thoroughly train them and then dispose of them to the best advantage, financially and otherwise. As the funds from the sale of this stock reverts to the experiment fund, this money may be used in financing the work of the future.

Much interest is being manifested not only in the West but throughout the United States in the outcome of this experiment. The correspondence coming to my office making inquiries concerning the success of the undertaking exhibits a very lively interest indeed. Already have there been a number of breeding establishments started along similar lines to the one undertaken here and an organization has been perfected in the East among the American Trotting horse breeders for the encouragement of the American carriage horse. At a number of the large state fairs of the Middle West, classes were established this year for this type of horses and liberal premiums were offered. I feel very safe in saying that no work that we have ever undertaken could have redounded more to our credit as an institution of research and demonstration than this one of developing an American type of horses. Plans have been perfected by the Government cooperating with other Experiment Stations in developing and encouraging them to take up similar lines of work with other breeds of live stock. In Minnesota the Department is cooperating with the Experiment Station in developing milking types of Shorthorn cattle,

while in Wyoming plans have been matured for the development of a type of sheep suitable for the range conditions. In Iowa the work of developing a draft horse suited to our conditions has been undertaken. All of these efforts have been the outgrowth of the work started at this Station. The success of the work here has made it possible to undertake the new lines at other stations.

APPROPRIATIONS.

The last state legislature were very liberal in appropriations to the Experiment Station. $6,000 was set aside for investigations along animal husbandry lines. An equal amount was given to the work in agronomy. Besides this, $2,000 was given for the erection of a much needed grain and storage building and a like amount for research work in farm mechanics and road building.

As before stated, these funds were not available for the Department until the month of October of the present year. Consequently, their use has been very much curtailed.

The additional land secured for experiment work through the purchase of 80 acres adjoining the experiment farm secured two years ago, has been of great service, but some portions of it are very foul with wild oats and other noxious weeds and these must be thoroughly eradicated before it can be of very great service to us.

With the special appropriations being available for the coming year, it should be a specially noteworthy one. If there is no unforseen setbacks, we feel that the next year will give us something to report that will be especially creditable to this Station.

Respectfully submitted,

W. L. CARLYLE,
Agriculturist.

Fort Collins, Colo.,
Dec. 1, 1907.

REPORT OF AGRONOMIST.

I hereby hand you a summary report of the work attempted and now under way in the Agronomy sub-Section of the Agricultural work of the Colorado Experiment Station.

This spring the Board purchased the Taylor addition to the Experimental Farm—80 acres. This the Agronomy Section used to grow the increase plots—several acres in each—of experimental grains and forage. The general rotation plan for the experimental plat section of the experimental farm is being carried out whereby we hope to carry on plat experimental work and, at the same time, demonstrate a practical rotation for an irrigated farm in this crop zone. Through distribution of definite types of small grains, forage and root crops, followed by crop investigation trips to study these types in their field environment we are seeking to place the most desirable types in their best environment. To help us in our work we have arbitrarily divided the state into three crop zones as follows:

A. Lands below 6,000 feet elevation under the ditch.

B. Agricultural lands in Eastern and Western Colorado without irrigation—above the ditch.

C. Lands above 6,000 feet elevation under the ditch.

Through an organization known as the Colorado Grain and Seed Growers' Association we now have the earnest support of some of Colorado's best farmers in this effort to improve the quality and yield per acre of our agricultural crops through Seed Selection.

The Colorado Seed Grain Competition, made possible through the Premium Fund donated by Hon. T. M. Patterson, of Denver, and the San Luis Valley Pea Prize Competition, made possible by philanthropic citizens of the San Luis Valley, are helping very greatly by showing what seed selection makes possible in crops in wheat, oats, barley and field peas. Through experiments now under way we seek to obtain helpful facts for Colorado farmers as follows:

1. Best varieties of wheat, oats, and barley for High Altitudes, for lower altitudes under the ditch and for non-irrigated Agricultural lands.
2. The best types of stock roots for Colorado conditions.
3. A Colorado type of alfalfa.
4. Relative value of animal and mineral fertilizers in sugar beet culture on Colorado soils.
5. Cultural methods for best results in growing sugar beets.
6. Rotations for different farm conditions in Colorado.
7. Cultural methods for alfalfa and small grain.
8. A desirable Colorado type of Dent corn.

9. Effect of irrigation on gluten contents of milling wheat
10. Forage crops for the non-irrigated lands of the state.
11. Best crop methods for each crop zone of the state.

Mr. F. Knorr, my assistant in the Agronomy work, has been very efficient and thorough in his work and though he has received many offers from other states his interest in our field experiments now under way have influenced him to continue with us.

We hope these Agronomy Experiments when worked out may aid our farmers in obtaining better gains without loss in soil fertility.

Respectfully submitted,

W. H. OLIN,

Dec. 1, 1907.

REPORT OF ANIMAL HUSBANDMAN.

The experimental work with live stock during the summer period has consisted principally in carrying over upon range pastures, twenty head of steers used in the three-year continuous experiment for determining the value of winter feeding of range calves, yearlings and two year olds. The plan of this work has been given in detail in previous reports.

The live stock feeding experiments to be conducted during the coming year are as follows:

THE STEER FEEDING EXPERIMENT.

The conclusion of the three-year experiment by winter feeding of two-year old steers, ending with their sale in the spring.

THE LAMB FEEDING EXPERIMENT.

A ration experiment with range lambs. The lambs have been divided into three lots and are being fed as follows:

Lot 1. Alfalfa hay and corn.
Lot 2. Alfalfa hay and barley.
Lot 3. Chopped alfalfa hay and corn.

The object of the experiment is to determine the comparative values of corn and barley when fed with alfalfa hay; and the comparative value of alfalfa hay whole and alfalfa hay chopped when fed with corn. The experiment will continue for a period of from three to five months.

THE HOG FEEDING EXPERIMENT.

A ration experiment with shotes.

Lot 1. Barley and corn, equal parts; alfalfa hay ad libitum.
Lot 2. Barley and corn, equal parts.
Lot 3. Corn.
Lot 4. Barley and durum wheat equal parts.
Lot 5. Barley six parts, tankage 1 part.

Respectfully submitted.

G. E. MORTON,

Fort Collins, Colo.,
Nov. 1, 1907.

REPORT OF THE VETERINARIAN

To the Director:

The launching of Veterinary College as a department in this institution combined with the extensive farmers' institute work over the state, has prevented, in a large measure, the consummation of plans laid out for work in my last report.

As veterinarian to the Experiment Station, I am constantly in receipts of appeals to investigate outbreaks of supposedly contagious diseases among all species of domesticated animals, and from every section of the state. My duties at the College under the present regime, prevent me from complying with most of these requests, as well as precluding the possibility of any extended research work.

LOCO WEEDS.

The investigation of loco weeds, cooperative with the Department of Agriculture, has been carried on to the present time, with headquarters at Hugo. There are at the present time, seven horses and seventeen head of cattle that survived the summers experiments, in a pasture near Hugo, awaiting the decision of the Washington authorities as to the expediency of continuing the experiments one more year. According to the term of an agreement with the federal authorities, we are obligated not to publish any results of the investigation until the work is completed, and the time of publication as well as the substance of report is to be by mutual consent. The entire experiment has been largely appropriated by the government experts in charge. The results obtained have been highly satisfactory from a scientific standpoint. Their economic value is conjectural.

NECROTIC STOMATITIS.

There is no other disease in the state at the present time that is causing as much apprehension as the so-called sore mouth disease of hogs. It has become widely spread and has decimated many large herds. It is found on almost every farm in several sections of the state. The disease has been known for a long time in the eastern states, but has not been reported as assuming any where near the degree of virulency as it has here. It is caused by a specific germ, the necrosis bacillus, and where as in most instances it has been confined to pigs under three months old, here it is fatal to swine of all ages. Ordinarily the disease is confined to necrotic areus in the mouth, and appears to be purely a local affection. In some instances within the last year, herds have been seen where hogs weighing over

200 pounds were near death, showing large necrotic sores and numerous abscesses on different parts of the body.

Source of Contamination.—The litter, feed troughs and everything that has been in contact with diseased animals, is a source of contamination. One diseased pig will soon infect the others by nursing and infecting the teats of the mother.

The germ does not develop on a healthy mucous membrane. It seems to develop in the mouths of small pigs when the germs are inflamed from the eruption of the teeth. It soon causes a large inflamed area which becomes necrotic and sloughs leaving large cavernous depressions which continue to grow deeper, until often there are holes clear through the snout, or the tongue is largely eaten away. The system soon becomes intoxicated with the secreted products of the germ which produces nervous depression and stupor. In this condition the pigs become careless of the teat and refuse to nurse, soon becoming greatly emanciated.

Treatment.—Prophylatic measures are effective if wisely and persistantly practiced until the infection is completely exterminated. The theropeutical value of drugs internally administered is questionable.

There is no other one thing concerning farm management and its relation to live stock, about which the average farmer appears to be so lacking in information as in the matter of preventing and effectively eradicating infectious diseases among farm animals.

Lethargy combined with not knowing how, has resulted in most cases of simply allowing the disease to continue until the loss is complete.

Four steps are necessary in the mastery of this disease.

(1) Destroy badly infected animals and burn the carcasses.

(2) Clean up the manure, litter and filth and destroy it by fire. Use disinfectants freely, such as 3% solution of zenolium or any one of several coal tar products, chloride of lime in proportion of four ounces to a gallon of water. White wash the buildings, fences, and everything that may have become contaminated. Burn sulfur in the buildings after closing up the windows and doors.

(3) Remove all animals that appear to be healthy to new quarters.

(4) Dip the little pigs when one week old in a bath composed of potassium permanganate, one ounce to a gallon of water.

The dipping may be repeated at intervals of two or three weeks. The mouths should be examined frequently and any necrotic sores burned out with lunar caustic, being careful not to burn the tongue.

HORSE TYPHOID.

Aside from a few autopsies in the vicinity of Colorado Springs nothing further has been done respecting this disease.

The etiological factor has not been determined and is a subject for the laboratory. The disease is not so widely spread or formidable as to warrant serious apprehension. The aggragate loss is not large but the mortality of animals affected is nearly 100 per cent.

The state of Nebraska has made a special appropriation for the purpose of investigating this disease.

HOG CHOLERA.

Hog cholera appears to have become a fixture in the vicinity of Denver.

The claim made by some that the disease in swill fed hogs adjacent to the larger cities was some disease other than hog cholera, has not been substantiated.

Susceptible hogs were exposed to the disease, by placing them in pens adjoining the sick ones. The usual number contracted the disease, and the symptoms and postmortem lesions revealed the identity of swill sickness and hog cholera. This fact was further substantiated by laboratory experiment and blood serum inoculations.

TUBERCULOSIS.

In reality we have no disease among the lower animals in the West that is commonly classed among the animal scourges. The nearest approach to it is tuberculosis. The disease is not as prevalent here as in the lower altitudes of the eastern states, but every state is being constantly infected by the importation of diseased animals. Aside from the probable menace to the human family it has become an economic problem of such vast proportions as to warrant stringent state and federal regulations.

Tuberculosis affecting several species of domesticated animals has become so general and its complete eradication by the usual methods adopted in exterminating contagiums, is such a stupendous undertaking that the authorities everywhere are overwhelmed by its magnitude and, comparatively speaking, are doing nothing.

Cattle and hogs are the most susceptible and in the latter disease is greatly on the increase.

A few spasmodic efforts have been made on the part of various cities to control the sale of tuberculous animal products for human consumption, (a few states have statutes perporting to regulate the traffic of tuberculous cattle).

The federal government is effectively controlling the sale of the flesh of such animals, for interstate and foreign trade. But until there is a united effort on the part of state and federal authorities to control diseased animals and all the products of the same, there will be very little accomplished.

GEO. H. GLOVER,
Veterinarian.

REPORT OF THE METEOROLOGIST AND IRRIGATION ENGINEER

Such lines of observations as are contained in the work of the meteorologist are the steady, persistant continuation of the series of observations planned and continued for the past twenty years. The value of such is in the length of the series, in the continuation under the same conditions and by similar methods. It is recognized that conclusions cannot be drawn short of a number of years, even concerning some of the simplest facts of climate.

A period shorter than 20 years does not give conclusive data regarding rainfall, temperature or agricultural meteorology. The observations have been directed, not to study the weather—that is done by the U. S. Weather Bureau—but the continuous record of those elements of importance in the growth of plants, temperature, moisture, evaporation, sunshine, and the amount of radiation received from the sun. But very little reduction has been made of the observations hitherto, but now with the completion of twenty years in most lines, it is time to do it. The work of reduction, of putting into shape, means toil far more than does the taking of the observations. The solar radiation, our measurements show, amounts to about 1 horse power per square yard.

The irrigation records of the year have been less with the idea likewise of working up the records available. The lack of room, the dangerous condition of our stores have been serious drawbacks. Records have been continued on streams, on seepage, and on the amount of water used in irrigation. Bulletins on three of these subjects are nearly ready for publication.

THE KANSAS-COLORADO CASE.

The year has seen the final ending of the attempt of Kansas to prevent the use of water in Colorado for irrigation. The final decision was given in May. Afterwards Kansas applied for a new hearing, but within a few weeks, the Supreme Court has again, and finally, declined. This case was largely, if not entirely, fought out on the lines which the investigations of this section had shown to be true; with the additional facilities on a larger scale, and with added wealth of fact and illustration. Immense amounts of records were made, hundreds of miles of levels, and the study of the underground waters for hundreds of miles. The original work has been done with the support of the Board, and therefore, as the credit is distributed, the policy and support of the Board in permitting and encouraging the records

which finally resulted in the victory, is to be recognized. It is a great satisfaction in the final result, for while I have believed that this should be the final result there has been considerable cause for fear, for the doctrine which we urged was contrary to precedent, and the accepted traditions of the east. I have felt and urged that the only way was to show facts and that the equity from the facts would force our case. It has not generally been realized how serious was the contention to the prosperity, not only of the Arkansas Valley, but of the whole of Colorado and of the West. The essential points were: First, a denial of the right to irrigate; and Second, by the U. S., as intervenor, that the United States should control the interstate streams. This last, was after all perhaps the most fraught with danger. It represented the continuation of the policy started in the attempt in the Elephant Butte case, which was not so much to prevent the construction of the dam, as it was to put the control of the streams in the United States. What dangers exist in the United States' control are already seen in the refusal of the general Government to grant land for reservoirs or ditches on the Rio Grande and the Grand River water sheds, on the claim that they might interfere in the one case with proposed schemes in Southern California, and in the other in Southern New Mexico and Texas. An assumption of the power to determine where water may be used, what regions may be developed, and the holding back of communities already well settled in Colorado, in favor of others as yet in the desert.

We have felt that while the investigations leading to these results were aside from those originally planned, that they were fundamental in the Colorado agriculture, and that nothing could be of more importance than establishing the right of the use of water.

For the next year, I now feel that it will be timely and better to bring up our observations than to enter upon much new work, unless there are additional facilities. The many plans elaborately prepared some 15 or 16 years ago, have been followed and all the varied work has been along a general plan and joining in a common end. Many of the plans then made were abandoned for lack of means, until better means were available, and the lines of work taken up were caused by the necessity of incurring small expense.

Respectfully submitted,

L. G. CARPENTER,

Irrigation Engineer.

Fort Collins, Colo.,
Dec. 1, 1907.

REPORT OF THE ARKANSAS VALLEY FIELD AGENT

To the Director:

I desire to submit the following report of the work in the Arkansas Valley.

As outlined, the work during the past season has been principally in line of plant breeding, to improve the three important crops of this part of the state, beets, alfalfa, and cantaloupes.

ALFALFA.

A new enlarged alfalfa nursery was established on a more suitable piece of land, than was first used; the old nursery having become infested with pocket gophers, and the area of uniform soil was limited. The new nursery was sown with seed from choice selected individual plants that had evidence of superior hay and seed producing qualities, and fifty varieties or strains of alfalfa from different states and from foreign countries, that was furnished through Mr. J. M. Westgate of the Department of Agriculture. In all the new nursery comprises sixty-four plats of two hundred hills of individual plants each.

The season was cold and rather unfavorable, yet a very satisfactory stand of plants was secured in most of the plats. A very marked contrast was revealed in some of the foreign strains, some of the plats had tall coarse stems with few leaves, others had thick fine stems very dense set with leaves. The variations in regard to the attack of leaf spot and the tendency to shed the leaves was very pronounced. The contrast in seed production if any thing was more marked than all. One plat sown with seed from Ecuador, South America, produced a remarkable yield of seed on nearly all of its plants, while many plats did not furnish enough seed to make a selection. Notes and photographs, and selections of seed have been made to carry on the work.

Observations have been made during the season on the cultural methods of growing alfalfa hay and seed, with a view of systematic study of the question.

BEETS.

Field observations on the beet crop have been made. The beet crop seems to have been quite generally affected with a leaf spot in this part of the state. Dr. C. O. Townsend pronounced it Cercospora Beticola, commonly called eastern leaf blight. It has seriously reduced the tonnage in this part of the State. Land in fine state of fertility has not been so badly injured as worn out land.

The small plat of mother beets for seed that were being grown to

test the different types of beets, failed to mature seed on account of the false chinch bugs, and other unfavorable conditions.

A test of about forty pounds of the "curly top" resistant beet seed that was produced last year was made with a farmer. The seed was sown at the same time with other seed and had the same care and yet it failed to grow seemingly weak in vitality. The general results in growing beet seed in this portion of the state have not been encouraging.

CANTALOUPES.

Of the rust-resistant cantaloupes, seed of ten that scored the highest in all points of quality were selected for the work the past season. The seed were planted in the same plat, which now for five years has been growing cantaloupes, enough to insure a failure of any ordinary strain of seed, but since the beginning of the resistant selection the plat has revealed a decrease in the presence of the disease, while in adjacent fields the rust has been prevalant as ever, and even more destructive. Except for a few individual plants the plat has been free from the disease. Several practical tests of the rust-resistant strain were made with the commercial growers in the vicinity of Rocky Ford, and in Indiana and Illinois, similar tests were conducted with growers of these states, through the cooperation of Professors C. G. Woobury and J. W. Lloyd of the Experiment Stations. Without exception the reports have all been to the effect that the rust-resistant seed had exceeded the highest expectations, remaining green and producing fine flavored melons after other varieties in adjacent fields were dead with the disease.

A comparative test was made of some varieties secured from W. W. Tracy to determine if there was any other variety that was more resistant to the disease, or that possessed better qualities for market or table, than the strain of seed that we were using. The result was that there was none that was considered better except one from Syrmna that seemed to have a better texture of flesh. An effort to combine this quality by hybridization will be attempted another year.

Also a test of eighty individual melons on alfalfa sod was tried to test the variations and to determine the laws of heredity in cantaloupes. The result of this research can better be given in a more extended report.

Respectfully,

PHILO K. BLINN,
Field Agent.

Rocky Ford, Colo.,
Dec. 1, 1907.

REPORT OF THE WORK AT THE PLAINS SUB STATION

To the Director:

It has been an exceptional year for Eastern Colorado, the worst in the history of the Station, the rainfall at the Station has been less than nine inches from October 1, 1906 to October 1, 1907, and nearly one-third of that at one time, on the 26th of June.

The lowest in any other year according to the Station records being the year 1903, when there were 13.26 inches.

On October 2nd, there were 10 acres of Turkey red fall wheat sown on ground that had been in spring wheat. After the spring wheat had been cut, the ground was well disked and the fall wheat was sown with a disk drill. The wheat was harrowed twice in the spring, but being so short, it was thought best not to cut with binder, so it was mowed, stacked and threshed, making a yield of three bushels to the acre.

On February 28th, there were 7 acres of Macaroni wheat sown, but being so dry, it came up very unevenly and was harrowed twice, was mowed and threshed, yielding 2 bushels to the acre, but of very good quality.

There was also one acre of wheat and two acres of oats sown, ground was disked and sown with disk drill, harrowed twice, for cultivation, but was thin, fairly well filled, and was cut for oat hay.

March 26th, there was planted one-half acre of early Ohio potatoes but during the heavy rain of the 26th of June, they were flooded all night and badly washed out. Will about get the seed back again.

On May 8th and 9th, there were eight acres of corn planted with the lister, but got very poor stand and badly taken by gophers, was cut and shocked but is now in the stack. Yield, one ton to the acre.

May 15th, there was one acre of Turkestan alfalfa sown, seed furnished by the College, but being so dry did not germinate until after the heavy rain of June 26th, and then was so badly washed that it was almost a failure. The other grasses which I sowed last year, such as bromis inermis, western wheat grass and slender wheat grass have about held their own.

The fruit was an entire failure, owing to the late freezes last spring, but was much better for the trees to rest during the dry season. The growth has been but light, they have held their own but by good cultivation.

The land is in fine condition to go into winter. While dry,

have all double disked twice, so if there is any moisture whatever it will take it in.

I also took up twenty acres adjoining the Station last June, 1906, plowed and packed it, resting the same till September. Twelve acres were sown to wheat, one bushel to the acre, Turkey red. The other eight acres were sown on September 20th, three-quarters of a bushel to the acre. The entire piece was harrowed three times in April and May, as cultivation. From the day it was sown till the 26th day of June, we had received but two and eleven hundredths inches of rain, this being the night of the big rain of the season. The wheat was cut within the next ten days. Where one bushel was sown the yield per acre was 17 bushels, while that where three pecks were sown, the yield was 21 bushels per acre. The same was all sold at the Station for $1.00 per bushel and sown, as dry as it continues.

Respectfully submitted,

J. B. ROBERTSON,
In Charge.

Cheyenne Wells, Colo.,
Dec. 1, 1907.

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Thirtieth Annual Report

OF THE

State Board of Agriculture

AND THE

State Agricultural College

INCLUDING THE

TWENTY-FIRST ANNUAL REPORT

OF THE

AGRICULTURAL EXPERIMENT STATION

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C. M. WOOD,
Leader of the Cadet Band. Residence, Court House.

HELEN M. GRENFELL,
Field Lecturer. Residence, Denver, Colorado.

J. F. TUTTLE, JR., LL. B., A. M.,
(Harvard), College Lecturer. Residence, Denver, Colorado.

LETTER OF TRANSMITTAL.

To His Excellency,

THE GOVERNOR:

Sir—Herewith I transmit my annual report as Secretary of the State Board of Agriculture. It is respectfully commended to your attention and to the thoughtful consideration of the General Assembly.

A. M. HAWLEY,
Secretary of the State Board of Agriculture.

The State Agricultural College,
Fort Collins, Colorado, November 30, 1908.

REPORT OF THE PRESIDENT.

The State Board of Agriculture:

Gentlemen—I submit herewith reports from the heads of the various departments of the Colorado Agricultural College, for the year ending November 30th, to which I invite your careful attention.

My own report at this time will be very brief, since it is my purpose to present at the end of my term of office a report covering the ten years of our co-operation.

It gives me unusual pleasure to state that there is perfect harmony in the College. Never has there been such evidence of solidarity. Never has there been a time when every member of the College, from the lowest to the highest, has been in more perfect accord with not only the members of his own department, but with those of all other departments. I am convinced, too, that the quality of work has never been surpassed. It would seem that every man not only feels the importance of his position, but is giving to it the full measure of his powers.

The student body, being almost without exception high-school graduates, is showing a college spirit and application to work of the finest sort.

There is a compactness, an *esprit de corps*, a marching together, which is most commendable. There are as many seniors as last year; twenty-five more juniors, eleven more sophomores, and three more of freshman rank, there being 112 in this year's freshman class.

The short course which began its work in November last has an enrollment of 106. There will be others entering after the Christmas holidays.

The student organizations are well officered, loyal to the administration, and performing remarkably well their several functions.

The faculty, united, is in that most desirable attitude of awaiting your instructions, determined that the policy of the board shall be its policy.

The support of the local press and of local organizations is given the College without reserve. I am confident that there has never been a time in the history of this institution when everything has so conspired to a great forward movement as will surely come under the efficient leadership which your wisdom will provide. If I may be permitted, I desire to submit a few suggestions.

I think I need not counsel you not to depart one iota from the letter and the spirit of the law which established and maintains these land-grant colleges as "high seminaries of learning,

where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts."

As in other States, that battle has been fought in Colorado and won on the side of the law and sane, approved, scientific education.

I desire further to call your attention to the high schools of the State. While we have cultivated their friendship and sent to them yearly a representative of the College with good results, the time has come when some one should devote all or the greater part of his time to cementing these preparatory schools and the Agricultural College. Not alone by a thorough visitation and an exploitation by models, samples and stereopticon lectures the work of this College, but by helping to so reshape their courses of study as to give better opportunity, certainly greater incentive to select such a high school course as will lead to this institution. Here lies one of, if not the most important work of this board and your faculty during the next five years.

I wish to again call attention to the demand for a four-years' industrial preparatory school to be established here under your supervision for the benefit of those graduating from the eighth grade who may not have high school privileges at home, and for those who may prefer more practical preparatory work than is usually provided in high schools.

One-third or more of our correspondence is in relation to such a school. The present faculty is willing to add to its duties the labor of helping to establish here such an industrial preparatory school, knowing the demand for it and fully realizing the great service it would render the College itself.

By an alternation of recitations and laboratory work with that of the College, as now scheduled, the present buildings would be ample. A head master and three or four additional assistants would be sufficient help for the first two or three years.

The faculty has with great care prepared a course of study for your consideration which they believe would meet the demands of such a school. I herewith submit a copy.

This preparatory school would double the enrollment of students at once. A small fee of from $10.00 to $20.00 a year could be charged under the laws governing the College which would almost cover the additional expense. It is worthy your consideration in the program of your growing College. It would complete the triangle of Agricultural College education. A preparatory school for the graduates of the common schools, which would either lead to the College courses or be more or less complete in itself for those who desire both practical and cultural education of a limited nature; next, the winter short courses already so successfully established for those who, older, lack either

time or means, or both, for a more thorough training; and then the long courses as now established, leading to the degree of B. S. for those who desire technical and special preparation in agricultural, veterinary, horticultural or engineering lines. All these statements relate as truly to domestic science for young women.

I believe some co-operative work should be undertaken with the State Normal School looking to the preparation of teachers of elementary agriculture in the rural schools. A beginning might be had by offering a summer school course at the Agricultural College, using our buildings, equipment and teachers, under the joint supervision of the College and the State Normal School. Before agriculture may be introduced into the common schools there must be a preparation for instruction in agricultural branches.

You should appoint at this meeting a legislative committee, whose special concern shall be the securing of much larger appropriations for the College from the Legislature. Either the permanent income must be increased to two-fifths of a mill, or greatly increased special appropriations obtained.

The College has outgrown its revenues. The increase of its extension work, which in no wise meets the present and constantly growing demands--a work so helpful to both the State and the College; the need for more buildings and new equipment, the increasing rate of living—making it necessary to increase the salaries of some of your employes—the greater demand for experimental work along many lines, all make it imperative that the claims of the Agricultural College shall be presented to the incoming Legislature as they have never yet been presented. The people are ready to help, organizations are proffering their assistance; you can double your revenues if you become urgent.

The animal husbandry department is at present in charge of Professor Morton; the department of agronomy is in charge of Professor Knorr; that of farm mechanics and dairying is under Professor Bainer; the farm and stock not otherwise supervised as above indicated are in charge of Mr. O'Brien, and the government horse-breeding plant under Professor Williams, sent out by the Department of Agriculture, at Washington, all reporting directly to the President of the College.

I have a few minor recommendations to offer later in this session relative to the immediate needs of the College.

B. O. AYLESWORTH.

REPORT OF THE IRRIGATION ENGINEER AND METEOROLOGISTS.

To the Director:

The development of the State of Colorado has been largely bound up with irrigation. Our station is the best situated of any in the Union for irrigation investigations. Extensive plans were made in the beginning, but the funds available made it necessary to postpone most of the investigations then proposed. An essential qualification of those taken up was that the cost was to be small, for during several years the sum available could not much exceed $100. This led to some projects, not such as would have been taken from choice, but from the necessity of the situation. Fortunately, some of these, whose merit was cheapness, proved to be of much value. Some of the questions relating to water-supply, to seepage matters, to measurement, were taken up. These became important because of the serious questions involving the fundamental water ownership and rights of the whole State. It was based on some of the investigations of the station that the successful defense of the State of Colorado against the attack of the State of Kansas was successfully made, and the result has been immediately seen in the activity in irrigation development since the determination of this question by the Supreme Court.

There has been a large amount of data in various lines, the results of measurements, of continued observations and of records, and it is now of pressing need that these be reduced and prepared for publication. This needs to be done to prepare for taking up other work in contemplation. The restricted quarters, the lack of laboratory space, has prevented the consideration of much work of importance and the laboratory tests in connection with plants and the use of water. With the new building, which it is hoped will be available during the coming year, this restriction will be removed and the limitations largely removed.

The danger to the valuable records has been a source of constant anxiety for some years back, but, fortunately, we have not suffered. There is, however, the constant risk. The same conditions have restricted the room and the opportunity for doing work requiring room.

The work of the past year has been along the lines of the plans adopted, and is the continuation of plans in force for some time. Special progress has been made in the reduction of some classes of the observations that now have become of great value. These it is hoped to systematically reduce. Without more room it is hardly possible to consider more aid for that purpose.

Respectfully submitted,

L. G. CARPENTER.

ANIMAL HUSBANDRY.

To the Director:

Dear Sir—The experimental work in live stock, as planned for the summer of 1908, has been carried out. The ration experiment with swine upon pasture was carried on for nine weeks, and has now been closed. Five lots of pigs, fourteen in each lot, were fed as follows:

Lot 1—Rape pasture; 1 per cent. of live weight in corn.

Lot 2—Rape pasture; 2 per cent. of live weight in corn.

Lot 3—Dry lot; corn at pleasure.

Lot 4—Alfalfa pasture; 2 per cent. live weight in corn.

Lot 5—Alfalfa pasture; 1 per cent. of live weight in corn.

Respectfully submitted,

G. E. MORTON,
Animal Husbandman, Agricultural Section.

Fort Collins, Colorado, November 1, 1908.

AGRONOMY SECTION.

To the Director:

Dear Sir—I hereby respectfully submit to you the following report:

No. 1. To develop a hardy type for higher altitudes.

No. 2. To develop a drouth resistant type for non-irrigated lands of the West.

The preliminary work for these experiments has been conducted in the alfalfa breeding nursery for three years. As soon as desirable stocks (hardy and drouth resistant) have been established in the nursery they will be taken to those localities for which they are specially adapted. Next spring we hope to send alfalfa stock to Gunnison.

No. 3. To develop a forage type for the irrigated lands which shall yield a desirable quality and increase the quantity of forage now produced by our present type of alfalfa.

In our plant-breeding nursery we now have alfalfa stocks from nearly all sections of the globe. Here we are testing the individuality of each plant, constantly adding new stocks that seem desirable and eliminating the undesirable ones.

Considerable close-hand pollenation has been done; by this means some excellent stocks have been developed. We now have more than 6,000 individual plants in the nursery; about two hundred of these are the specially selected hand pollenated stocks.

CORN.

No. 1. To breed up an acclimated type of dent corn which shall possess more desirable physical characteristics and be hardy for altitudes from 4,000 to 6,000 feet.

This work has now been in progress for five years. Although this work is making good progress, it is a question in my mind if this would be of any advantage to the farmers of the irrigated sections. If this work could be continued on dry land, it would be of greater value to the farmers of Colorado.

BARLEY INVESTIGATION.

No. 1. To obtain a desirable drouth-resistant barley, without beards, for lands above the ditch.

For this work all possible beardless varieties that could be secured were planted in the spring of 1908. Several beardless varieties in the nursery were crossed with our best bearded varieties, in order to seure desirable types of beardless barleys.

No. 2. To obtain a good quality, high-yielding feed barley, without beards, for irrigated lands below 6,000 feet.

This work is along the same line as the above.

No. 3. A very early type for the higher altitudes.

A number of very early maturing stocks from the College were placed in several localities at an altitude of from 8,000 to 10,000 feet. This year these stocks proved fairly satisfactory.

No. 4. A more desirable malting type for irrigated lands.

Nothing has been done with this, and it may be advisable to drop this work.

MEADOW AND PASTURE GRASS INVESTIGATION.

Nothing has been done with this, except that a number of stocks have been planted in the plant-breeding nursery.

OAT INVESTIGATION.

No. 1. Development of a superior milling oat for the higher altitudes of the inter-mountain region of the West.

This was carried on in the regular plant-breeding work in centgener plots. This work will be continued in the nursery for several years.

No. 2. Do the various types of oat differ in drouth-resistant power, and can this be intensified in breeding by selection?

Nothing was done with the above.

STOCK ROOT INVESTIGATION.

To determine the best type of roots, under Colorado conditions, for economical feeding of beef, pork and mutton.

For the past two years a number of varieties of stock roots were planted, with the object of selecting varieties best adapted for Colorado conditions. In the fall of 1908 it was considered a good plan to cross some of our mangles with the sugar beet, in order to secure a better keeper than the common mangles.

Several very good stock carrots were saved from the 1907 crop (these were planted in my home garden, and seed was grown from these); that year over 75 per cent. of the carrots died from rot. It is hoped that this seed will prove rot resistant.

SUGAR BEET EXPERIMENT.

No. 1. To determine the effects of various fertilizers and manure upon purity and sugar contents of the beets; the residual effects of commercial fertilizer and manure upon the soil; crop rotation by continuous culture.

This was carried out as planned, and is now in its third year.

No. 2. Cultural methods, including tillage, seeding, harvesting and siloing.

This was carried out as planned. The results of this work are most gratifying.

No. 3. Determine the minimum amount of water that will grow a maximum crop of beets.

This was carried on as planned, with the exception that the water used was not measured; the plats were simply irrigated one, two, three, four and five times.

SPRING MILLING WHEAT.

To determine the cause of deterioration in spring milling wheats on the irrigated lands and in the higher altitudes. In connection with this project wheat was grown by the Experiment Station and three co-operators in three different sections of the State. One of the co operators at Carbondale, altitude 6,100 feet; Alamosa, 7,546 feet, and Rocky Ford, 4,180 feet. This is the first year of the work. As soon as the milling apparatus and necessary equipment can be installed, the milling tests will be carried out, as outlined in the plan.

Respectfully submitted,

F. KNORR,
Acting Agronomist.

Fort Collins, Colorado, November 1, 1908.

FARM MACHINERY.

To the Director:

Dear Sir—I hereby respectfully submit the following brief report of experimental work in farm mechanics:

Last April these outlines of work were submitted to be carried out between then and June 30, 1909. The subjects of these outlines were as follows:

Cement posts for farm use.

Feed grinders, cutters and crushers.

Farm buildings and construction.

The first subject—"Cement Posts for Farm Use"—is just completed, as far as the experimental work is concerned. The data have been secured and are ready to be written and arranged in bulletin form. We desire to get this material in shape for publication by November 30, 1908. Neither of the other two subjects has been started.

We hope to carry out the second line of work—"Feed Grinders, Cutters and Crushers"—between now and June 30, 1909.

It seems necessary to omit the last line of work for the present time on account of the limited amount of help in the department and the large amount of instructional work to be given.

About $1,200 out of the $2,000 appropriated by the State for experimental work has been used during the past summer for erecting additional machinery space for the department machinery. This space is in the form of an addition to the old farm mechanics' building and covers a space 36x66 feet. It has ten-foot posts with floor above for light machinery.

Mr. H. B. Bonebright, assistant in farm mechanics, has spent about one-half of his time since last January working with the cement fence post experiment. I have also spent a great deal of my time during the past six months in the same line of work.

Respectfully submitted,

H. M. BAINER,
Professor of Farm Mechanics.

Fort Collins, Colo., November 1, 1908.

REPORT OF HORSE BREEDING INVESTIGATION.

To the Director:

I beg to submit to you a brief report of the horse breeding investigation as conducted in co-operation with the U. S. Department of Agriculture for the period beginning with my appointment as expert-in-charge, October 22, 1908, up to the present time.

STUD RECORD SUMMARY.

There are at present in the stud seventy-six (76) animals, consisting of the following:

1 stallion.
28 mares in service.
8 two-year-old fillies.
2 two-year-old colts.
4 two-year-old geldings.
7 yearling colts.
9 yearling fillies.
9 male foals.
8 filly foals.

76 total number in stud.

There have been no additions made to the stud during the time aforementioned, but the above summary includes the mares and foals purchased during the summer and their addition to the stud is of such importance as to deserve special mention at this time. The purchase was made by the original purchasing board composed of Mr. Geo. M. Rommel, Animal Husbandman of the Bureau of Animal Industry; Prof. W. L. Carlyle, Expert in Animal Husbandry, and Director C. F. Curtiss, of the Iowa Experiment Station. The mares purchased represent blood lines that are producing the best carriage horses in Kentucky. Three were sired by Wilson's King, and the fourth by Chester Dare, the grandsire of Ahma, second prize carriage brood mare at the 1907 Blue Grass Fair. This is the best blood that can be obtained in Kentucky at the present time and its introduction into the experiment should prove very valuable in the results attained.

The mares were all in foal when purchased, and all have foaled since purchasing. The mares, Barthania, McCord and Elvira Lindsey were bred back to Bourbon King, and the mares Golden Picture and Bethel Princess were bred to Golden King before being shipped to Colorado. Some of these mares will be eventually mated with Carmon, and the refinement and quality

which is characteristic of these blood lines should be of great value in the production of carriage horses of the proper type.

ELIMINATION OF UNDESIRABLE ANIMALS.

A number of animals in the stud at the present time have been recommended for disposal. There are fifteen animals in all to be culled and include the following:

Mares:

Brown mare—California.

Bay mare—Florida.

Chestnut mare—Minnesota.

Three-year-old fillies:

Brown filly—Idalia.

Bay filly—Monella.

Two-year-old filly:

Bay filly, out of Idaho.

Two-year-old geldings:

Brown gelding, out of California.

Brown gelding, out of Illinois.

Yearling fillies:

Chestnut filly, out of Minnesota.

Bay filly, out of Michigan Lady.

Yearling colts and geldings:

Bay gelding, out of Illinois.

Bay colt, out of Wisconsin Queen.

Foals:

Chestnut filly, out of Minnesota.

Bay colt, out of Florida.

Bay colt, out of Monella.

Of the above recommendations, one has already been disposed of; the yearling colt, out of Wisconsin Queen, having been destroyed in accordance with a board resolution passed during the last meeting.

The above recommendations were submitted to Dr. A. D. Melvin, chief of the bureau of animal industry, by the former board of survey composed of the members of the purchasing committee aforementioned.

The recommendations have been favorably acted upon by the department and the animals the property of the department ordered to be sold by the present board of survey composed of the writer as chairman, Prof. C. F. Curtiss and Mr. Geo. M. Rommel.

The animals the property of the department which were condemned and recommended to be sold are the mares California,

Florida and Minnesota, and the three-year-old fillies, Monella and Idalia.

The remaining condemned animals are the property of the experiment station and are subject to sale at its discretion. I trust some suggestion will be submitted as to the best manner of disposing of these animals. As it is quite essential that the identity of these animals with the experiment be lost, because of their inferior qualities, the manner of disposing of them deserves some deliberation. It has occurred to me that it would probably be advisable to place them in some good market, such as Omaha or Kansas City, and allow them to bring whatever the open market afforded. This would insure a total loss of identity, but on the other hand a slight sacrifice of proceeds of sale might occur. The matter, however, is left to your discretion, and I trust some recommendation will be made for their sale, as the horses should be disposed of at once.

IMPROVEMENT.

The improvements made have been only those of urgent character. Two sheds have been built approximating an expenditure of about $200.00. Water lines have been installed in three paddocks, the remaining paddocks having been previously equipped with water.

MAINTENANCE OF ANIMALS.

The majority of the brood mares are kept on pasture in the foothills with a daily allowance of upland hay. The mares with foals, stallions, young stock, and mares which do not thrive on pasture are kept at the barns for constant attention.

The young stock is maintained on a ration of oats, alfalfa and upland hay. They are very thrifty and are growing nicely.

CONCLUSION.

The development of the young stock indicates that progress is being made in attaining the proper type of carriage horse. With the condemned horses eliminated, and a continued process of judicious breeding practiced, the outcome of the experiment can be none other than successful.

Respectfully submitted,

J. O. WILLIAMS,
Expert in Charge.

Fort Collins, Colo., Dec. 8, 1908.

REPORT OF THE VETERINARIAN.

To the Director:

There are at the present time no animal diseases threatening the security of the live stock interests of the State. There are, however, a few diseases that are a constant menace to this industry, and while at the present time none of them has assumed the proportion of an epizootic, yet in the aggregate they claim an annual mortality that makes the raising of live stock as a business more or less hazardous.

These diseases are at all times to be reckoned with, not only because of a certain small loss, but because of the danger of their assuming wide-spread proportions and not only claiming the profits of the business, but a goodly proportion of the principal invested as well. The specific cause, prevention, and treatment are as yet little understood and are problems which can only be mastered by diligent scientific co-operation of field work and laboratory.

The most important diseases within the State, named casually in the order of their probable economic significance, are as follows: Tuberculosis, mostly in cattle and swine; necrotic stomatitis in hogs and calves, poisonous plants on the open range, black-leg and anthrax, strangles in young horses, hog cholera, mange of cattle in the western half of the State, scabies in sheep, contagious abortion, parasitic diseases, calf scours, swamp fever in horses, and glanders.

LOCO WEED INVESTIGATION.

This is the fourth season of our co-operative investigation of the loco weed problem in conjunction with the department of agriculture. This undertaking has been co-operative only to the extent that we have furnished the live stock. One thing seems to have been determined beyond what the western "cow man" already knew, and that is the specific nature of the poison, which, according to the report of the biochemic division of the bureau of animal industry, is barium. As an addition to science this discovery alone has unquestionably justified the investigation. The practical solution of the loco problem, however, does not rest with the discovery of the causative agent, but must be prophylactic or curative to have any economic value.

As no information has been furnished us regarding this season's work, I am unable to report anything definite. The efforts of the U. S. Department of Agriculture to bring to light

the long hidden mysteries of this perplexing problem in the interests of science and a great western industry are certainly worthy of commendation and warrant the generous appreciation and co-operation of the western stockman.

NECROTIC STOMATITIS.

During the winter months a year ago this disease reached the proportions of a veritable scourge among the swine in almost every section of the State.

The disease assumed a degree of virulency never before reported. Thousands of young pigs died and older ones in many cases succumbed. The specific organism (bacillus necrophorus), which, no doubt, is responsible for this condition, is also an invader in hog cholera outbreaks, and the post mortem as well as ante-mortem lesions, in necrotic stomatitis, range all the way from those characteristic of this disease to those typical of hog cholera.

Necrotic stomatitis is commonly spoken of as sore mouth disease in pigs and calves. This name, however, is a misnomer, as the mouths are often not in the least affected.

In some cases we find ulceration of the walls of the stomach, with deep-seated necrotic areas, and tumefaction of the muscular coats. In most every case, deep sloughing sores may be found on the feet, tips of the ears, nose, or in some unusual place on the surface of the body.

Control of the disease seems not to be difficult when active measures properly directed are adopted. A thorough, systematic quarantine and disinfection have been recommended by letter, through the press, and by personally visiting the diseased herds.

The things especially recommended have been the removal of healthy animals to new quarters, the burning of all litter, disinfecting feed troughs, and dipping all the hogs once, and the little pigs every three days, in a solution of potassium permanganate, one ounce to one gallon of water.

HOG CHOLERA.

The conditions for raising hogs in Colorado approach the ideal. This fact is becoming appreciated, and, as a result, hog-raising has taken an impetus in the last two years, which augurs well for the future of this industry in Colorado. Hog cholera has not as yet caused much loss, and there are those who make the sweeping claim that hog cholera and other contagious diseases need not be feared because of the favorable climatic conditions in the arid West.

These claims, in the main, are not substantiated and the danger is that we become overzealous in this respect and relax our vigilance in necessary quarantine and sanitary measures. We have already lost enough hogs from cholera in the West

to effectually refute such ill-advised statements. The fearful loss from hog cholera in this country actuated the U. S. Department of Agriculture to undertake a thorough investigation, with the hope of securing a remedy or, better still, a means of protecting hogs against this disease.

After several years of diligent research, an effective means of immunizing hogs against cholera has undoubtedly been secured. That this product, known as Dorset's hog cholera serum, will protect hogs against the disease cannot be doubted. The objections to it are two-fold, viz., the expense in its manufacture, and the danger of distributing the virus among careless veterinarians and uninformed farmers.

The Kansas experiment station has undertaken to produce a protective serum by passing the cholera virus through the horse. The claim is made that this method will successfully protect the hog against hog cholera, and at the same time avoid the objectionable features of the Dorset method.

While it is practically certain that we now have a sure method of preventing the spread of hog cholera, the fact remains that farmers are themselves largely responsible for the spread of the disease, and the education of the farmer as to the nature of the micro-organism which causes disease is, after all, the principal safeguard.

In accordance with your instructions, arrangements are now being made to start in the work of making the Dorset hog cholera serum. It is doubtful if the serum can be made and administered in remote sections of the State for less than forty cents a dose. We shall undertake the work in a limited way and enlarge upon the work if circumstances warrant us in so doing.

Respectfully submitted,

GEO. H. GLOVER,
Veterinarian.

Rocky Ford, Colorado, October 23, 1908.

L. G. Carpenter, Director:

The efforts of the field agent at Rocky Ford, during the past season, have been largely confined to the alfalfa seed breeding investigations, attempting to develop a better type of hay and seed yielding alfalfa; also endeavoring to determine the conditions and cultural methods necessary for the highest yields of alfalfa hay, and a more uniform production of the seed crop.

The results of these efforts may be briefly summarized, in the following observations and results, from the plats of different varieties and individual selections, all under the same conditions. Marked contrasts of practical value were revealed, in hardiness, in early spring development, frost resistance in spring, and in the tendency to lodge, with wind and rain. The character of the stems, and profusion of the leaves desirable for hay, and the tendency to good yields of seed, were variations of still more interest and value. Some of the plats would easily have produced double the yield of hay; of others, and of the sixty-four plats, comparatively few produced any seed, yet several were almost phenomenal in this respect; as high as four and one-half pounds from one hundred and seventy-five plants, that grew on one plat of two square rods; some individual plants produced as high as two ounces of seed. The plats of relative high merit were selected, and all the seed that was possible from them saved to continue the work in this line. About thirty-five pounds of seed was secured, ranging in amounts from one-half to four and one-half pounds from a plat.

Considerable effort was devoted to the study and determination of the principles that underlie the setting of alfalfa seed. The indications point to two factors: Weather conditions, and hereditary tendency. The latter may be controlled by seed selection, it is evident almost beyond doubt.

The experiments with the cantaloupe for disease resistance have been more of secondary consideration, as the results of our investigation in this line have been so manifestly successful that it is now clearly the work of the practical seed breeder rather than the experimenter.

It is gratifying to report that the practical merits of the "Rust-resistant" strain of cantaloupes developed by the Station is receiving recognition from growers; not only in the vicinity of Rocky Ford, but from the whole United States inquiries and reports are coming in. This strain is being extensively planted, and except for the one objection, its late maturity, it would soon become the exclusive strain. But as the earlier maturing cantaloupes capture the highest prices, and net the grower the

greatest returns, the early strains will still be grown to a large extent, even though they are expected to go down with disease. It is an unfortunate condition, for the diseased melons demoralize the markets with poor and uncertain quality, thus injuring the returns for the later cantaloupes of even first quality.

Disease resistance and early maturity, is a combination much needed. To get this result, the rust-resistant strain has been hybridized with the earliest strain, using the cross both ways. The final results of such an effort may require several years to accomplish, yet the indications promise decided results, as one of the selections from a hybrid of the second generation matured early, and was strongly resistant to the melon blight. The seed of this selection will be submitted to a field test this coming summer. One of the plants that was used in the crosses this season matured ripe cantaloupes in thirty-five days after the flowers were pollenated, which is nearly a week earlier than the average early strains. Several other hybrids were made this season, with a variety from Smyrna, and one or two other varieties that we have secured from the United States Department. The specific objects of these crosses were to improve the quality of cantaloupes, and to trace the laws of heredity in the melon. These hybrids, and a comparative test of some material secured in previous work in this line, constitute the extent of the cantaloupe investigations the past year.

The sugar beet investigation has been rather inert, for several reasons. The spirited controversy between the factory management and the farmers, and the unfavorable season, due to the shortage of rains and irrigation water, has discouraged any effective co-operative work. Outside of some general field observations, little has been attempted in this line. The sugar beet industry in the Arkansas valley has been severely injured this season by unfavorable climatic conditions, and the prevalence of the "curly top" trouble, root aphis, and several of the fungus diseases of the beet. Our investigation in developing a beet resistant to the curly top resulted last year in a failure of the seed to germinate, thus terminating at present the efforts in this line.

On several occasions during the summer assistance was rendered the Farmers' Institute corps under Prof. H. M. Cottrell. Addresses were made at Rocky Ford, Hotchkiss, Bristol, Hartman, Granada, Amity, Holly, Cortez and Mancos. An address on breeding cantaloupes was prepared and read before the American Breeders' Association, at Washington, D. C., January 26, 1908. Also, another article was prepared for the Denver Chamber of Commerce, on the subject of the cantaloupe industry.

The above is submitted as the general report of the field agent at Rocky Ford.

Respectfully submitted,

PHILO K. BLINN.

Cheyenne Wells, Colorado.

To the Director:

I desire to submit the following report on the above farm, situated in Cheyenne county, Colorado:

The year just passed has been an exceptionally dry one, less than ten (10) inches of rain having fallen during the entire year, and this season about three and one-half (3½) inches up till the first of August. During the month of August about two and one-half (2½) inches, and on the 18th of October about five (5) inches, making a total for the year of about eleven (11) inches.

The spring being so unusually dry, planting and seeding was all done quite late. The 6th of May there was seven (7) acres of ground sown to macaroni wheat; on the 8th of May there was five (5) acres sown to side oats, which did but little good, and on the 19th and 20th of June was ruined by hot winds. Weeds were in evidence on this ground, notably the Russian thistle, and this, with what little wheat and oats remained, were cut for cattle feed, making about a ton of feed to the acre.

On the 13th day of May there was eight (8) acres planted to corn, but, owing to the dry weather, did but little good, and on two different times was materially damaged and ruined by hail; was planted over to cane on the 20th of June, and was left stand to pasture in the field. On the 3d of June there was ten (10) acres planted to cane, which yielded about a ton of feed to the acre. On the 10th of June there were eight (8) acres sown to hersey grass, which germinated very slowly, and which came up very uneven and made a very small crop, and was well mixed with Russian thistles.

Garden of a general character, as well as potatoes, were put out, but proved an absolute failure.

THE ORCHARD DIVISION.

Trees have done no good at all; no fruit on account of the late freezing in the spring, and the trees have made no noticeable growth. The two dry years of the past have drawn all the moisture from the ground, and has so remained until the big rain of the 19th of October.

Many trees show the effect of dead limbs in parts of the tree. The orchard proper was deeply cultivated the early part of October, in anticipation of some moisture, so that the rain that did come was thoroughly saved, and therefore the orchard goes into the winter in as fair condition as can be expected after the prolonged drought.

There have been sown fifteen (15) acres of fall wheat (turkey red). This wheat was sown during the past month. Also, five (5) acres of rye have been put in.

Dated this 9th day of November, A. D. 1908, at Cheyenne Wells, Cheyenne county, Colorado, and respectfully submitted.

Yours truly,

J. B. ROBERTSON.

REPORT OF DIVISION OF AGRONOMY.

To the State Board of Agriculture:

Gentlemen—I hereby submit to you the following report:

CLASS WORK, COLLEGE COURSE.

Last spring, at the close of the college year, the curriculum for the agricultural students was revised. By this change much work has been added to our teaching, but the department of agronomy feels that by this change the course is strengthened, and better fits the student for his chosen work.

The students that were graduated from the agronomy and live stock work last spring have returned to the farm, feeling that, with the knowledge gained here, the farm affords the most remunerative work. It is hoped that, with the new course of study, which covers a wider range, a larger number of young men will be educated to take up farming from a scientific standpoint.

The work in soils is not so extensive as it is where a special department of soils is established. Up to the present time we have been able to teach only the rudiments of "soils." This portion of the work should be strengthened.

The classes in field crops will receive more work this year than in the past. In order to make this more thorough, we should have a small greenhouse. Such a structure need not be more than 10 x 15 feet. The study of the growth of grain, etc., in connection with their classroom lectures, is very essential. The students are not here during the growing season of the grain and grasses, so some substitute should be provided.

COLLEGE REPORT FOR 1908.

The farm management class of senior students has been developed into extremely practical work. Through the kindness of the Denver & Rio Grande Railway Company transportation was given to the seniors, so they were enabled to visit several of the most successful farmers along their route and study methods of farming. Thus, by combining the practical with the theoretical, they appreciate more keenly the value of their education, and they also realize the tremendous field of work that lies before them.

PRACTICAL COURSES.

The practical course work has increased very rapidly. Teaching the short-course students is more difficult than the reg-

ular college students, since in most of the agronomy work text books can not be used. The texts on field and forage crops are not suited for our work, going too much into detail, for which our time is too limited; besides this, most of the material does not apply to our crops under our varying conditions. Likewise, the texts on farm management are not adapted to our State. Nearly all of this is lecture work and discussions, in which the students take great interest.

FARMERS' INSTITUTES.

Whenever possible, and when not conflicting with the regular college work, the writer assists, so far as he is able, in the institute work. This year he has attended thirteen institutes, besides acting as judge of grain exhibits at a number of fairs throughout the State.

Respectfully submitted,

F. KNORR,
Acting Agronomist.

Fort Collins, Colorado, November 24, 1908.

ANNUAL REPORT DIVISION OF ANIMAL HUSBANDRY.

To the State Board of Agriculture:

Gentlemen—I respectfully submit the following report:

EQUIPMENT.

The live stock teaching work has been strengthened by the purchase of Hampshire ewes, and could be made still stronger by the addition of some long-wool sheep.

There is not dairy stock enough available for class work and either Jerseys or Guernseys should be purchased, as recommended in a previous report.

CLASS WORK.

The teaching work was carried very satisfactorily this year; but the new long course, and the practical course present a schedule of teaching which fills practically the entire day, from November until the middle of March. Not over half of the time of the head of the division should be given to teaching, as the correspondence and overseeing of College stock requires about one-fourth of the time, and experimental work one-fourth.

If some farmers' institute work is to be done by this division during the summer, assistance is needed for the entire year, otherwise only during the winter months.

Respectfully submitted,

G. E. MORTON,
Head of Division.

Fort Collins, Colo., November 1, 1908.

ANNUAL REPORT OF DEPARTMENT OF BOOKKEEPING AND FARM ACCOUNTS.

The State Board of Agriculture:

Gentlemen—I herewith submit the annual report of the Department of Bookkeeping and Farm Accounts.

BOOKKEEPING.

At your biennial meeting held in April, 1907, you authorized a one-year bookkeeping course. Since that time very little has been done in the way of advertising this course. Owing to this fact the attendance has been small.

The small attendance is due, largely, to lack of advertising the work and the tuition fee attached thereto. I am strongly in favor of abolishing the tuition and allowing students to register for this work the same as in other courses offered, i. e., free from tuition; also to recognize the course in the way of advertising.

The work for this course, as I have outlined, is the same as the subjects taught in the junior year of the old commercial department and requires high school preparation.

Should you see fit to act favorably regarding my request, I am satisfied you will see a large increase in attendance, besides meeting the approval of many.

FARM ACCOUNTS.

The students in the practical course in agriculture will enter the class of farm accounts early in November, at the opening of the short-course term. Last year I had two divisions in this class and this year, from the present outlook, the attendance will be much larger.

The instruction given is to show the application of the fundamental principles of accounting to the every-day routine of general farming. The system used is simple and practical, one that will meet the requirements of the farmer, dairyman, fruit grower or stockman.

HOUSEHOLD ACCOUNTS.

During the first term of the practical course in domestic science the students take up the subject of household accounts. They are taught how to keep accounts in the home, accuracy in taking care of the receipts and disbursements, and in balancing and proving their work. The use and care of checks, receipts, drafts and notes, etc., are taken up and discussed with good results.

Respectfully submitted,

CHAS. G. DWYRE, JR.

Fort Collins, Colo., October 29, 1908.

REPORT OF DEPARTMENT OF CHEMISTRY AND GEOLOGY.

November 10, 1908.

To the State Board of Agriculture:

Gentlemen—I have the honor to present the following statements pertaining to the Department of Chemistry and Geology:

The instructional work has followed the requirements of the courses as given in the catalogue from year to year. There have been changes in the work, necessitated by changes in the other departments. These changes have, in my opinion, been of doubtful advisability.

I would be very glad to extend the course in chemistry, but I believe it to be inexpedient under the circumstances. The complaint of the students now is that they have not the necessary time to do more. We have endeavored to maintain a fair standard of work in the department, and we believe with reasonable success. The work in general chemistry continues through one year; two terms are devoted to the study of general inorganic chemistry and one term to the organic chemistry. The laboratory work is devoted largely to qualitative work and to such special lines as are required by the other departments.

Geology is studied for one term. We have an excellent suite of rock samples and a good collection of fossils for the illustration of these subjects. Our collection of minerals is limited, and while our samples have some merit as individual specimens, we need a collection of the common minerals which are met with in common rocks.

The short-course work in the department lasts about five weeks, daily recitations. We can only hope that the results of this work are more satisfactory to the students and others than to ourselves. It may be that the time is well spent in doing this class of work, but general chemistry has in the years that we have had this work seemed too specific and difficult for the student to whom it has been presented.

The interior of the building under my charge has been painted since my last biennial report, and its appearance greatly improved. So far as I know, the building is in good repair.

Respectfully submitted,

WM. P. HEADDEN,
Professor of Chemistry and Geology.

REPORT OF DEPARTMENT OF CONSTITUTIONAL HISTORY AND IRRIGATION LAW.

The State Board of Agriculture:

Gentlemen--The work of this department since the date of the last semi-annual report requires but brief mention.

The summer vacation was spent in attending the various teachers' normal institutes in the different districts of the State, representing the interests of the college, and making from one to three addresses before each institute. The work required an approximate travel of 5,000 miles within the State.

During the fall term classes have been conducted in agricultural economics and in international law, in the regular courses, and in government and irrigation law in the practical five months' course.

During the winter term there will be classes in advanced history, in political economy, in irrigation law, and in the law of contracts, all in the regular four-year courses.

For the zeal and attention and conduct of the students in all classes I have only words of compliment.

With my acknowledgments to the president of the college, and to each member of the faculty for their constant courtesy, I am, Very respectfully,

W. R. THOMAS,
Professor of Constitutional History and Irrigation Law.

Fort Collins, Colo., November 15, 1908.

REPORT OF DEPARTMENT OF DOMESTIC SCIENCE.

To the State Board of Agriculture:

Gentlemen—I have the honor and privilege of presenting my annual report concerning the work, condition and needs of the Domestic Science Department. It gives me great pleasure to report that the work has been very gratifying in the past year. The continued approval of the students and the public is reasonable assurance that Domestic Science work is being recognized and is regarded as helpful. In presenting these matters to your consideration, it must be said that our work is comparatively new work, and, therefore, real needs exist if there is to be progress in the future.

Our greatest need is a new building. During the past summer this building was thoroughly cleaned. The bath tubs were removed and the bathroom changed into a fitting room. In the basement the walls were repaired, and now with new paper, paint and good walls, the building is clean and attractive.

The heating system is very unsatisfactory, and on cold days last winter it was impossible to heat this building. When working in my office, I had to wear a heavy winter coat and felt the cold very severely. My stenographer and everyone else who was in the office with me always complained of the cold room. The basement is never warm until noon, and, as we have classes there from 7:30 on, it is very hard on the students and the teachers.

During the summer Professor Lory changed the lights. They are now adjustable, and very satisfactory.

The laundry is found to be too small to do good work. I wish that something might be done. We are using the small kitchen to help us out and the wet clothing has to be carried through the long hall, making confusion and a great deal of extra work. If a large room could be secured in some other building, and our old equipment used, the expense would not be great. The present laundry could be used as a cold storage room, as we have no place in which to keep our refrigerator and supplies.

Last June eleven girls were graduated in the two-year Normal Course; three in the General Science Course, and four girls were graduated in the Short Course. This year the attendance is only about one-half of what I expected, but I be-

lieve it is due to the publicity given to our college this last summer. The following students are now enrolled for this year:

Freshman	10
Sophomore	3
Special	7
First Year Short Course	17
Second Year Short Course	8
General Students	5
Graduate Students	1

The Normal Course was taken out last year, and also the Sub-Freshman class, which accounts for part of the loss in attendance. On account of change of courses two years ago, there are no Juniors or Seniors this year.

The one-week Short Course work in Domestic Science is growing rapidly. Last year there were three Short Courses held in various parts of the State and this winter there will be ten. In my opinion, this is the very best way of helping rural districts and small towns. It is practically taking the college work to these women who are unable to leave home and who are anxious and eager to learn the most modern methods of housekeeping. About eighty women registered for the Short Course held in Fort Collins last January. Requests are coming in every day asking for the date of the next one. Circular letters are to be sent out and we hope to have a splendid program for the week's work. Great interest seems to be taken in Domestic Science all over the State. At the Farmers' Institute work during the summer it was a real pleasure to address the gatherings of men and women as they seemed to think our work was not foolish, but of real practical help. Miss Brush and Miss Boswell assisted in the Farmers' Institute work this summer. Miss Margaret Ross and Miss Edna Pughe, two of last year's Normal graduates, have been secured to assist us in the Short Course work this winter.

Miss Crawford resigned last spring to accept a position in the University of Wyoming as instructor in Domestic Science. Miss Inga Allison, of Lake Erie College, was appointed to take her place. She is very capable and will be a great help to this Department. As far as I know, everyone in this Department is working in the greatest harmony, and each teacher is doing her best to uplift the work and to keep up a high standard.

I wish to ask for fifty dollars per year for my department, to be used at my discretion and to be placed at my disposal by January 1. This money will be spent carefully and an account of every cent rendered at the end of the year. It could be called an emergency fund. This would include the purchasing of extra groceries, sewing materials, and utensils, sometimes for extra

work such as having a woman come in for a day to launder the curtains and fine linen or to do housecleaning before school opens after a vacation.

Many requests for help have come from the club women of the State. About twenty outlines for club study have been sent in answer to these requests. I have been trying to get the club women interested, as I feel that it will be through them that we can get the work put into our public schools. I have been trying to work in this vicinity and have succeeded in inducing the Woman's Club of Windsor, and the Woman's Club of Fort Collins to give one-third of the year to Domestic Science. In other cases a few days will be given during the year. Last year I gave talks on Housekeeping at Colorado Springs, Denver, Windsor, Loveland, Fountain, Greeley, Pueblo and Fort Collins. During the year a physician and a trained nurse gave several lectures to our students. Mrs. Sarah Platt Decker, of Denver, gave a splendid talk to the students in April.

The National Federation of Woman's Clubs has done this College the honor of appointing me a member of the Domestic Science Committee, and the State Federation has made me chairman of the Domestic Science Department. At the meeting of the Federated Clubs in Colorado Springs, several people from other States asked about the Short Course work in Colorado. One woman who was there from Cincinnati, Ohio, invited me to give a week's Short Course in that State, but it was not possible for me to do so. I feel that the Short Course work is very important and very helpful.

Mrs. Guldlin, of Fort Wayne, Indiana, who is chairman of the Domestic Science Department of the National Committee writes me that she will put our work before all the women in the United States in the next two years, as she thinks the Short Course program of this State better than any other. I mention this because I think our State Board should know what we are trying to do. There is much to be done and it will take years to do it.

Last January at the State Teachers' Association meeting in Denver a Domestic Science Section was formed and we hope through this means to get the teachers of the State interested in the work. The officers have given us two mornings at the meeting in December, and if these meetings are successful we will soon have the work in many places in the State. In this way through the teachers of Domestic Science we will come in touch with high-school pupils and thus increase our enrollment.

The Foresters who took the Short Course last year asked for some special lessons in camp cookery and the request was granted. Last winter four lessons in camp cookery were given to a class of twenty-five of the College boys.

A donation of a fine gasoline mangle has been made to the Department by the American Ironing Machine Company. Pro-

fessor Lory has installed a fine electric stove. In this way we are able to teach the girls how to manage institutional or hospital work. I am glad the library is to be open evenings during the Short Course, and wish that it might be open the whole year, as the evening is the only time when students and teachers can get much benefit from the books.

The Science Association meeting was held here in the spring. Our students gave a luncheon to the visiting students and teachers, which was very much appreciated.

The Domestic Science Department got out a Domestic Science Special "News Notes" in April. This has been widely circulated and hundreds of requests have been received in this office for a copy of it.

The Theodosia Ammon's Memorial set of books were received in March and placed in the library. The books are used daily and will be a beautiful memorial for many years to come.

The physical culture classes are progressing nicely and it is to be hoped that some provision may be made whereby baths may be put into the gymnasium dressing room.

A dormitory is desirable.

During the year an outline of thirty lessons in Domestic Science for rural teachers was prepared and printed. Copies are sent free to any teacher in this State and on payment of a fee of twenty-five cents to teachers of other States.

I regret exceedingly that on account of a Short Course week at Del Norte and two lectures at the Corn Exposition in Omaha during the second week in December it will not be possible for me to entertain the State Board of Agriculture at luncheon until the spring meeting.

The things asked for in this report are most conservative, based upon real needs, and I commend them to you for your favorable consideration.

Respectfully submitted,

MARY F. RAUSCH.

REPORT OF DEPARTMENT OF CIVIL AND IRRIGATING ENGINEERING.

To the State Board of Agriculture:

Gentlemen—I have the honor to submit my report as Professor of Civil and Irrigation Engineering for the current year.

The crying need of the Department at present, as it has been for some years past, is for a suitable building. For many years we have outgrown the present building, and the pressure for room has been so great that it has been necessary to dismantle some of our apparatus, and to adjust ourselves to the quarters, such as they were. This has meant a curtailment of the work we have felt was desirable to do for the students, and has prevented us from doing many other things which we believed were desirable and would be of benefit both to them and to the State. The need for this has been recognized by the Board.

The Legislature of 1903 made an appropriation of $40,000 through the efforts of the Senator from this district, Hon. W. A. Drake. After the bill was passed the contract was let and excavation made and some of the foundations put in when it was determined by the State Auditor that the revenues of the State were such that the appropriation could not be paid. In consequence the work had to be suspended, and thus it has remained for nearly five years. In the meantime there have been some revenues collected by the State Treasurer which were credited to the revenues of 1903-4, with the result that about a year ago this fund was credited with about $15,000 which was available for carrying on the work. This amount was too small to complete the building as planned, and it was a question how it could best be used in connection with the original plans. To change the plans so as to make a building that could be completed within this sum would not materially relieve the Department, and it was considered by all means best to retain our original plans and to build as much of the proposed building as possible. The amount was not sufficient to inclose the proposed building, but through the aid of additional funds set aside by the State Board of Agriculture, a contract was let which would enable the building to be inclosed, omitting some external parts which could afterwards be added, and omitting all interior finish.

This building as planned is 60x120 feet in extreme dimensions, consisting of two ends of the full width of 60 feet, and connected with an inner portion of 40 feet in width. It provides an assembly room large enough to seat 200 persons on the sec-

ond floor, with several class rooms that will seat as many as 50; a large room adapted for exhibits of irrigation and engineering apparatus, with office rooms for the Department, also an hydraulic laboratory fitted with an hydraulic tank, in which to carry on laboratory experiments; drafting rooms, and general facilities for instruction, together with additional rooms for use in connection with the Experiment Station.

During the existence of the Department a large amount of very valuable data has been collected, and it has been always a cause of apprehension that fire might destroy the records that have thus accumulated, and which would be impossible to replace. Their value is more than of ordinary scientific interest. They have already proved of great value, for instance, in the attack on the irrigation of the State by our neighboring State of Kansas, when the accumulated knowledge and records of this character had a great deal to do with the success in protecting the interests of the State.

The new building is of white brick and will be an ornament to the grounds, and one which we can look to with great satisfaction.

The need of the Department is to finish this building so that we may occupy it at the earliest possible date. By finishing this it will relieve the building which we now occupy so that it may in turn be used to relieve some of the pressing needs of other departments which have outgrown their present quarters.

The present plans of the building were made when a central heating plant was in contemplation, so that there is no provision for its heating. It was thought that a structure, temporary or permanent, as the case may be, could be built back of the building, at a cost less than would be required to change the plans of the present structure and to include a chimney. The appropriation ought to be enough to complete the building and to equip it. The equipment calls for the furniture for the offices, lecture rooms, cases in the museums, hydraulic tank and standpipes, and various other hydraulic and engineering laboratory apparatus, so that the total amount required for this would be $40,000 to $50,000; the smaller sum would not be sufficient to completely do so.

In some previous reports I have called attention to the line of usefulness for the Department and College by instruction in roads. This would be a natural supplement to the work that is being done. There is considerable need, and some organized desire for instruction of this character. A systematic course of study in roads is worthy of consideration. An instructor could be provided at an initial cost of from $1,200 to $1,500 per annum, with some equipment, meaning a total annual cost at present of from $2,000 to $3,000. Such an instructor is needed in the College and in the Institute work, and should be provided for in the near future if it is not considered timely at present.

The general work of the Department has proceeded with a fair degree of satisfaction. The principal difficulties have been those connected with small quarters and the necessity of adapting the work to the current situation.

The Field Camp, which has become an important feature of our work, and a very important element in the instruction of the students in engineering, was this year taken to Pike's peak. Through the courtesy of the mayor and council of the city of Colorado Springs we were permitted to use their building at Seven Lakes as the headquarters of our camp. It is at an elevation of 10,900 feet. With this as a center, surveys were made of existing reservoirs and proposed reservoirs in that vicinity. Besides that there were extensive engineering works within a moderate distance. The reservoirs of the city of Colorado Springs; reservoirs of the Pike's Peak Power Company; the power house at Skagway; the mines at Cripple Creek and Victor; the cog road up Pike's peak, and numerous other important structures within a moderate distance. The camp was pronounced one of the most successful we have ever had, at least in that respect. The cost was also less than the camps of the past few years, principally because of less teaming being necessary, and also because of a systematic effort to keep down some of the expense of the commissary.

Students have shown a commendable interest in nearly all of their work. The record of the graduates has been very good and gives increased satisfaction in their success. The Department has felt first that it was important to turn out men who were good citizens and who would be an element in their communities. In addition, it has endeavored to turn out men of such skill that they would be sure of support, and to give them such an outlook upon methods of engineering that with opportunity they would be on the road to acquire skill and ability. The record of many of the graduates was given in the last printed report. It did not include all. The list could be extended with names and with the creditable work of others. The graduates have made their mark in irrigation and hydraulic work in many enterprises which relate to the development of the West.

Respectfully submitted,

L. G. CARPENTER,
Professor Civil and Irrigation Engineering.

L. G. Carpenter,

Professor Civil and Irrigation Engineering.

Dear Sir—I submit herewith the following report of my work in your Department for the year ending December 1, 1908:

During the months of December, January and February I traveled over the State and visited all the high schools, and many of the lower grades, inspecting the work done in the different schools, addressing the student body at each place upon the merits of the Agricultural College, work done here, and the advantages one secures by coming here. This trip is what we call the high school trip, and is the one that has been taken by Prof. J. W. Lawrence heretofore.

Returning to Fort Collins about March 4, I had charge of the following classes during the spring term:

Senior class in hydraulics. There were nine students in this class and all did good work.

Sophomore class in agricultural hydraulics. There were fifteen students in this class and the work done was acceptable.

Sophomore class in irrigation engineering. This class was made up of seventeen students, and was fair. The class seems to be weak in many ways, and their work with me in irrigation engineering shows a number of failures and conditions.

The sophomore class in drawing met in the afternoon and they covered practically the same ground that has been covered by all classes in this course.

I also had charge of the junior class in drawing for one-half of the term.

During the summer months I spent the time as a member of one of the institute squads, and together with Dr. Glover, Prof. Cottrell, Dr. Newsome, and others, we held Farmers' Institutes for about eight weeks.

The first two weeks of this term were spent in Field Camp at Seven Lakes, about twelve miles west of Colorado Springs. The work consisted of the survey of a reservoir storing the waters of Beaver creek, the seniors having charge of the dam site survey and also the topography of the reservoir. The high water line contour was run by the juniors and sophomores. Surveys were also run for reservoirs No. 7 and No. 8, lying further up in the mountains. We also took occasion to visit the different points of interest in this region, going over the entire Cripple Creek district and also inspecting the engineering works already completed in the Seven Lakes district.

The classes taught during this term are as follows:

Junior class in hydraulics. There are twenty-eight students in this class, and the work as a whole has been poorly done.

Senior class in meteorology. The thirteen students in this class have done acceptable work in every way.

Twelve students in the photography class have also done good work.

At the present time I am giving to the second year short-course students lectures on the principles of irrigation. This class has twenty-six students in it, and all seem to be greatly interested in their work.

The afternoons have been spent with the junior class in hydraulic laboratory. We spent the first part of the term rating meters at the College lake, after repairing the damage done to the station last winter by the ice. At present we are at work rating the streams in this vicinity, and will continue on this line of work throughout the remainder of the term.

Respectfully submitted,

E. B. HOUSE,
Associate Professor of Irrigation Engineering.

REPORT OF DEPARTMENT OF ENGLISH.

To the State Board of Agriculture.

Gentlemen—In the main, the work in the Department of English is being carried out as outlined in the catalog. In addition to the regular work we have two students taking subfreshmen English, and one student, a junior, taking special work in grammar.

At present we have the following classes:

		No of Students.
(1)	Class in Sub-Freshman English	2
(1)	Class in Special English	1
(3)	Classes in Freshman English	87
(1)	Class in Sophomore English	15
(1)	Class in Senior Logic	13
(1)	Classes in Parliamentary Practice and Citizenship	19
(3)	Classes in Practical Course English	46
	Total (11) Classes	193

Miss Carscadden, a graduate of the University of Nebraska and a teacher of experience, is first assistant in the department. Mr. Iddings, of the Agricultural Department, has kindly consented to take the work in Parliamentary Procedure and Citizenship, and Miss Baker, a graduate of the University of Colorado, is helping correct themes.

The Practical Course students in English have been divided into three divisions based upon their present efficiency in English, and not upon grades from other schools attended. A student will be promoted from one class to the next higher as soon as he is worthy of advancement. "It is up to the student."

We are pleased to note that the library is now open in the evening. Heretofore, the students in our department have complained that they have had no time to do work in the library.

The most efficient work in the department would necessitate additional help.

Respectfully submitted,

B. F. COEN,
Professor of English.

November 14, 1908.

REPORT OF THE DEPARTMENT OF FARMERS' INSTITUTES AND COLLEGE EXTENSION WORK.

To the State Board of Agriculture.

Gentlemen—The Farmers' Institute and College Extension Work for the year ending November 15, 1908, has been as follows:

	Attendance.
128 Farmers' Institutes	20,285
7 Special Meetings	600
23 Train Institutes (1,583 miles)	5,005
12 Farmers' Short Courses	1,401
3 Domestic Science Short Courses	1,034
Total	28,325

The total number of sessions at all institutes was 240, and the total attendance at all sessions was 33,605. Forty speakers connected with the College and thirty-three from outside took part in the work. The expense for the year was $7,886.33.

In March, 1908, the Denver & Rio Grande Railroad furnished free to the College a Potato Institute train of four cars and ran the train over 1,583 miles of their track. The baggage car contained all the implements and equipment needed for growing potatoes in Colorado. Three passenger coaches were used for seating audiences to hear lectures on potato growing. The College sent seven lecturers on this train. It stopped at 23 towns, and 28 meetings were held attended by 5,005 people. The result was a large increase in the acreage planted to potatoes in the territory covered by the train. F. A. Wadleigh, Assistant General Passenger Agent of the road, accompanied the train and aided very much in extending its usefulness.

In June, 1908, F. S. White, Agricultural Commissioner of the Rock Island-Frisco Railroad, invited the College to hold Farmers' Institutes along the Rock Island Railroad in Colorado, working in connection with him. Institutes were held in eleven towns, the lectures being given in halls. Following the lectures, the audience visited the exhibition car of the Rock Island-Frisco System.

All the railroads except the Burlington and the Missouri Pacific have given our lecturers free transportation to attend Farm-

ers' Institutes and this aid has enabled us to double the number of meetings we have been able to hold with our appropriation.

In 1907, Prof. Wendell Paddock held at Delta a week's Short Course in Fruit Growing, the first Short Course held in the State outside the College. It was so thoroughly appreciated and such a marked success that it was decided to have the Farmers' Institute force spend the winters in holding Short Courses, adapting each course to the special needs of the locality in which it is held.

From January to March, 1908, there were held at places outside the College twelve Farmers' Short Courses with a total enrollment of 2,435. Each Farmers' Short Course was held for six days and each Domestic Science Short Course for five days.

To secure a Farmers' Short Course 100 subscribers were required, each paying a fee of two dollars, and fifty subscribers at one dollar were required for a Domestic Science Short Course. These fees paid about half the expense to the College.

The Short Course is the most thoroughly appreciated and the most valuable extension work done by the College. It permits the giving of extended information on subjects of special importance to those who attend.

A readjustment is necessary in the Farmers' Institute and Extension Work of the College. The members of the Experiment Station and College forces feel that in justice to their other work they must reduce very materially the time spent in Institute and Short Courses. At the same time to meet the needs of the farmers of the State more than double the number of Farmers' Institutes should be held with at least seventy-five Short Courses each year, and new lines of work are urgently needed.

In the past two years many thousand farmers have come to the State. Most of them are unacquainted with the conditions and methods that secure the best results in Colorado. They need help from the College. If they succeed, they bring thousands of other settlers to the State. Their failure means a permanent injury. For the benefit of the State, the College should hold a Farmers' Institute in every settlement where new settlers are numerous.

There were held during the year all the Institutes which the funds would permit and that with the free help of the faculty. With the instructors of the College finding it necessary to do less Institute work, more outside help will have to be employed.

Our appropriation was exhausted early in September and there have been many requests for Farmers' Institutes that had to be rejected on account of lack of funds, and a good part of the State has not been sufficiently covered. In the three northwestern counties of the State no Institutes were held because there was no money. These three counties have an area one-half

greater than Massachusetts, and when properly farmed will become one of the most productive sections of the State. In those sections of the State where Institutes were held there were not funds to hold a sufficient number, e. g., there are 70 stations on the lines of the Union Pacific Railroad in Colorado and many settlements off the railroad where Farmers' Institutes are needed. We were able to hold Institutes at but 12 places in all this territory.

Besides the additional work needed in Farmers' Institutes and Short Courses, the Farmers' Institute Department should take up two lines of work that have proven very efficient in promoting Agriculture in other States—Correspondence Courses in Agriculture and Boys' and Girls' Clubs.

There are thousands of new settlers on Colorado farms who need information throughout the season on problems that come to them in the new conditions under which they are working. Such problems as preparation of the soil and varieties to plant at different altitudes, when and how to apply water, methods of culture, how to feed Colorado crops, and prevention of insect depredations and plant diseases. Besides specific information they need to be taught the principles underlying farm methods peculiar to Colorado. A Correspondence Course fills this need and can be adapted to the special wants of each farmer.

There are more than 60,000 boys and girls over 14 years old of school age in Colorado. The Farmers' Institute Department should organize these boys in school districts and township clubs to grow grains, potatoes, sugar beets, melons and field peas, to feed Colorado crops and to study methods and markets. Each year a Boys' Institute should be held in a township at which the products grown by themselves compete. The prize-winning products of each township should compete at a County Institute and the winners in each county should enter a State Contest. Similar work should be conducted in cooking and sewing with the girls.

The Boys' and Girls' Clubs would not only enthuse the members in developing the agriculture of the State and give them valuable training, but it would have a strong influence in the same direction on their parents.

The expenses for the work of this Department last year were $7,886. With less help from the Faculty there will be needed the equivalent of the time of two thoroughly trained men all the year. This will cost at least $3,600, or a total of $11,486. If $25,000 is appropriated for the coming two years, it will furnish only $1,000 a year to extend the old work and to start the new work needed. Double the amount could be expended with profit to the State.

Respectfully submitted,

H. M. COTTRELL.

FARMERS' INSTITUTE AND COLLEGE EXTENSION WORK

For Year Ending November 15, 1908.

	College Staff	Farmers' Institutes	Special Meetings	Train Institutes	Short Courses	Total
1	Dr. R. W. Corwin	..	..	..	1	1
2	Hon. E. H. Grubb	3	..	28	4	35
3	President Aylesworth	..	..	..	9	9
4	F. C. Alford	13	..	..	..	13
5	H. M. Bainer	17	..	..	..	17
6	E. R. Bennett	32	1	28	8	69
7	P. K. Blinn	7	..	..	1	8
8	H. B. Bonebright	3	..	..	..	3
9	Rebecca Boswell	7	..	..	..	7
10	Emma Breining	..	..	..	3	3
11	Mary J. Brush	5	..	..	..	5
12	L. G. Carpenter	1	1	..	5	7
13	W. L. Carlyle	5	1	..	2	8
14	H. M. Cottrell	57	1	28	10	96
15	Elizabeth Cutler	..	..	..	1	1
16	Marguerite Frink	5	..	..	..	5
17	R. W. Gay	..	..	..	1	1
18	C. P. Gillette	10	..	..	10	20
19	G. H. Glover	8	..	..	4	12
20	W. P. Headden	1	1	..	6	8
21	E. B. House	21	..	..	2	23
22	E. J. Iddings	7	..	..	..	7
23	S. A. Johnson	15	..	..	..	15
24	H. E. Kingman	3	..	..	..	3
25	Fritz Knorr	13	..	..	..	13
26	B. O. Longyear	1	..	..	..	1
27	C. A. Lory	5	..	..	..	5
28	G. E. Morton	20	..	..	4	24
29	I. E. Newsom	11	..	..	..	11
30	W. H. Olin	6	1	..	..	7
31	W. Paddock	14	1	..	7	22

32	L. F. Paull	8	..	..	1	9
33	R. B. Parshall	8	..	..	..	8
34	Mary F. Rausch	8	..	..	5	13
35	W. R. Thomas	..	..	..	1	1
36	J. F. Tuttle	..	..	..	3	3
37	Geo. P. Weldon	2	..	..	..	2
38	Echo Ward	..	..	..	2	2
39	O. B. Whipple	14	..	..	5	19
40	Hon. F. E. Brooks	1	..	..	..	1

FARMERS' INSTITUTE AND COLLEGE EXTENSION WORK.

For Year Ending November 15, 1908.

	Outside Speakers	Farmers' Institutes	Train Meetings	Short Courses	Total
1	E. M. Ammons	1	..	4	5
2	B. G. D. Bishopp	9	..	..	9
3	E. R. Bliss	..	28	5	33
4	Prof. W. G. Chambers	1	..	..	1
5	J. H. Crowley	2	..	..	2
6	Sam Dell	..	28	..	28
7	J. W. Downey	8	..	2	10
8	H. L. Edgerton	..	26	..	26
9	C. L. Fitch	2	..	1	3
10	E. J. Foreman	1	..	2	3
11	Robert Gause, Jr.	..	..	1	1
12	F. Gaylord	..	..	1	1
13	J. A. Girardett	1	..	..	1
14	Chas. Green	..	..	1	1
15	O. C. Gregg	2	..	6	8
16	Gov. E. R. Harper	..	..	8	8
17	J. H. Johnstone	1	..	..	1
18	Anna Kihme	..	..	3	3
19	G. W. Martin	..	..	1	1
20	H. W. Moore	1	..	1	2
21	C. F. Mason	7	..	..	7
22	E. Matthews	..	..	3	3
23	H. F. Palmer	..	..	1	1
24	J. E. Payne	1	..	..	1
25	A. R. Pierce	3	..	..	3
26	C. H. Rhodes	7	..	..	7
27	I. Rothchild	1	..	..	1
28	E. Sherman	..	21	..	21
29	A. T. Steinel	1	..	..	1
30	E. Smith	..	..	2	2
31	W. G. M. Stone	..	..	8	8
32	W. H. Vassar	2	.	.	2
33	F. S. White	11	..	..	11

DEPARTMENT OF FARM MECHANICS AND DAIRYING.

To the State Board of Agriculture.

Gentlemen—I hereby respectfully submit the following third annual report of the Department of Farm Mechanics and Dairying:

Early in January Mr. H. B. Bonebright was secured as Assistant in Farm Mechanics and Dairying to fill the vacancy made by the resignation of Mr. W. G. Hummel.

During the past year eight classes have been taught in lecture room work, and eight classes in laboratory work. This includes work given in both the four-year course and the Practical Short Course. During the present term we are giving instruction to four classes in lecture work and three classes in laboratory work.

Twenty Farmers' Institutes have been attended during the year by members of the Department.

At one time last winter it became necessary to give instruction work to fifty-five Short Course students at one time. Under these conditions it became necessary for us to divide the class into two sections, and to give the instruction in two different places at the same time. Our class room is entirely too small to handle as large a class as this at once.

Very little additional machinery has been secured during the past year on account of not having room in which to store it. During the past summer an addition 36x66 has been erected to the south end of the Farm Mechanics' Building, and we are now very well equipped with storage room. Our present Farm Mechanics' Inventory shows a valuation of $11,275.00, and the Dairy Inventory shows $1,150.00.

Considerable correspondence has been carried on during the year on both Farm Mechanics and Dairy subjects. Some experimental work has also been carried on by the Department.

Respectfully submitted,

H. M. BAINER,
Professor of Farm Mechanics.

Fort Collins, Colo., November 1, 1908.

REPORT OF DEPARTMENT OF HISTORY AND LITERATURE.

To the State Board of Agriculture.

Gentlemen:—I have the pleasure to submit herewith the annual reports of (1) the Department of Literature and History, and (2) of the Dean of Women.

The regular scheduled class work, which includes five courses offered in history, and five in literature, has been conducted during the past year, and in addition to this, a course of lectures in American History has been given for the girls of the second year in the five months' practical course.

The industrial history of the United States has been introduced as an appropriate addition to the Agricultural and General Science Courses, this branch being taught for the first time this year.

At the beginning of the fall term the dormitory, which has been the only home for college girls under college control, was abandoned, and I was asked by the President to secure homes for the girls in private families, and to provide plans for the same college supervision for all. By the assistance of Miss Carscadden, who is able to relieve me of a part of my class work, I have been able to devote the necessary time to this work of the supervision of the interests of the college girls. The following general regulations have been found desirable, and have been adopted with the full co-operation of the lady teachers and student girls:

(1) No women students are assigned rooms in houses where any rooms are rented to men students.

(2) Gentlemen company is allowed only in the parlors, and never in private rooms.

(3) Company is allowed in student boarding houses only on Friday, Saturday or Sunday evenings, not on the evenings of regular school days, and not later than ten o'clock, excepting by special arrangement.

(4) Chaperones are required for all parties given by students.

(5) In general the young women are encouraged to exercise their own good judgment with regard to matters of conduct, and to be considerate of the rights of others in the homes where they are received.

Many of the best homes in Fort Collins have been opened to students under this plan, and most of the girls board and room at the same place. I have, by frequent visits in these homes, received very satisfactory reports regarding the home life of our student girls. We have at present as fine a class of young women as has ever been enrolled at C. A. C. One hundred and three is the total enrollment to date in all departments.

The Lecture Course, conducted for the last five years in the interest of the social needs of our young women, has been arranged for this year, as usual, to consist of five members. In addition to these five special entertainments an hour or so for social intercourse has been secured, by the co-operation of other departments, on the first Thursday afternoon of each month. The lady teachers, and often the wives of faculty members, join with the girls in these gatherings.

It is believed that wholesome College spirit, and devotion to C. A. C. ideals and interests will be fostered by these plans.

Permit me now to call attention to some of the needs of student girls:

(1) More adequate representation of their interests in our faculty councils.

When I entered the faculty there were fourteen members, two of them women, or about fourteen per cent. of the entire number. Since that time, by the action of your honorable body, the faculty has been increased by fifteen additional members, all of them men, making a total of twenty-nine who were listed in the last catalogue, so that the proportion is now but two women members in a faculty of twenty-nine. During a part of the year, the demands of the extension work leave me the only representative in the faculty councils of the particularly feminine interests of the College. I earnestly request that Miss Kettle, who has been for the last four years the head in fact of the Department of Modern Languages, be recognized as a member of the faculty, and so be given an opportunity to join in our deliberations upon matters of College policy.

(2) Better accommodations in connection with gymnasium work.

We require of every girl three hours per week in the gymnasium, but provide no decent facilities for the dressing room. The water and sewer pipes are already in the room used for this purpose, and at a trifling expenditure several wash bowls and appropriate partitions to provide privacy in the dressing room could be secured. Shower baths would also be desirable, but provision for water in some form is imperative. Our lessons in personal hygiene are contradicted in practice every day. I most earnestly urge the attention of the Board to this matter.

I would also ask you to confirm by your action my appointment by the President as Preceptress of Women, and to increase

my salary by an amount in proportion to the additional responsibility which I have been asked to assume. I have served the College for eight years, and during that time have had the pleasure of rejoicing with some twenty of the others of the faculty who have been encouraged by an increase in salary. Only five of the twenty-nine members of the faculty, besides our President and Secretary, have had a longer term of service than mine, and I feel that upon assuming the additional duties which I have been urged to accept this fall, my salary should certainly be increased to $1,800.

During the past few years I have been making a study of the conditions for women in the agricultural colleges of our country, and the opportunities they offer for women students. You may be glad to know that the work I have done along this line has been accepted by my Alma Mater at Ames as a thesis, and that the degree of Master of Philosophy was conferred upon me at the commencement last June.

I am always glad to acknowledge as a direct benefit to my Department any extension of library facilities. The recent provision for evening opening is a great accommodation to my students, and I trust that the plan may be continued.

Respectfully submitted,

VIRGINIA H. CORBETT.

Fort Collins, Colo., November 15, 1908.

REPORT OF THE DEPARTMENT OF HORTICULTURE AND BOTANY.

To the State Board of Agriculture:

Gentlemen—I have the honor to present the report of the Department of Horticulture and Botany for the past year.

The instruction in the Department has been given according to schedule and the interest on the part of both students and instructors has been good. Your attention was called to the fact in a former report that a change in the course of study was desired. This change has been accomplished, much to the benefit of all concerned, as we are now able to give more specialized work along the lines which the student may elect.

The Department never was in so flourishing a condition as at present. More students have enrolled for the course than ever before, and there is little that we need in the way of equipment, outside of greenhouses, that can be provided.

Mention was made in the last published report of preparations which were making for a fruit growers' short course at Delta. This course proved to be a great success, and the movement has taken a hold on the people, under Professor Cottrell's direction, so that now more calls are received for these courses than can possibly be met. We have been glad to give our time to help get the College extension work well started, but the time is now at hand when other arrangements must be made. Indeed, the demands on our time, both summer and winter, have been so great that experiment station work has been neglected. Possibly this result is inevitable, as the executive work and correspondence of the Department are assuming large proportions.

Respectfully submitted,

W. PADDOCK.

THE LIBRARY.

Fort Collins, Colorado.

To the State Board of Agriculture:

Gentlemen—The following report, concerning the College Library, is respectfully submitted:

The report is arranged under five heads: Functions, Equipment, Maintenance, Miscellaneous and Statistics. A general statement and description may be found in the annual catalogue and in previous reports.

FUNCTIONS.

The Library of this College is a general service office and not like a department. The service is to all departments and all the College.

This College is a technical institution, offering courses in the various phases of the subjects grouped about the soil and its products, a limited scope of engineering, domestic science, industrial sociology and the current, local student interests. We require a scientific library of reference and research, and our policy is plainly an intensive collection of books in direct response to our College environment. Our specialties (arranged alphabetically) are agriculture, domestic science, engineering, horticulture, industrial sociology and statistics, and public health and welfare. Subjects such as botany, entomology, history, language, literature, veterinary medicine, etc., are included or are contributory.

In addition, we have to assume, in part, the functions of a public library, because there is no large public library near us. The current student interests, including literary and debating societies, require books and service, and there is actually no limit to the student and public demand made upon a comparatively large library situated as this is.

Both for the sake of prestige and service, this Library must be notable as an intensive collection rather than a mass of nothing in particular, resembling hundreds of other inconsequent collections. This should be a scientific Library of reference and research within our specialties, and this report is devoted to an emphasis of that point of view.

We are one of four or five libraries in Colorado that rank higher than the others in size, equipment and service. We can hold that rank only by performing our intensive functions with whatever of maintenance we may have. We are just approaching

a knowledge of our functions, and this particular statement is put forth now because we stand upon the threshold of our library activities and at the beginning of library history in Colorado. Our progress and success depend upon careful plan and policy of an intensive collection liberally supported.

In the nation this Library is one of several similar libraries, many of which are perfunctory and of little service through failure to appreciate the importance of definite functions. On the other hand, there are those that understand this matter so well that they have skimmed the cream of our specialties (and other specialties) while we were idle or without means. This is true in the literature of irrigation, the history of agriculture, and in every department under the heads given in the alphabetical list at the beginning of this topic. This is going on all the time and grows more intensive and permanent as institutions increase their efficiency and responsibilities demanded in modern life. It is surprising to discover the real extent of this rivalry in collecting special material in our own lines.

In brief, our functions are plain enough, and a detailed statement is superfluous. It remains with us to provide for a collection in response to the present demands and to project the efficiency of this Library into the future of the College, so wonderful in its educational promise. We should take immediate measures to collect the history and practice of irrigation and agriculture in Colorado, and elsewhere. We shall have to go to market for nearly everything, and the sooner the cheaper.

EQUIPMENT.

Our book collection, in some part, has been in storage for seven years, because we have insufficient shelving, inadequate floor space or some similar want to hinder service and retard growth. Library progress must sit and wait for long periods while equipment crawls up to our station point. We have tons of material unavailable, and our reading room space is so cramped that something should be done for student accommodation. Our equipment is far behind our service. The inventory of the Library shows a value of $40,000; it is desirable to have such a collection in a fire-proof building.

DOCUMENTS.

We have a very valuable collection of documents of the United States. It is probably second to none in the Rocky Mountain region, and, as a collection, it is unusual in the West. We have spent a great deal of time on it and one portion alone (U. S. Dept. of Agriculture and the State stations) is worth $2,000. Our designation as a document depository is but three years old in effect.

Our serial set of congressional documents in sheep binding lacks only 300 pieces (out of 5,200) of a complete set, and we

have practically completed several "departmental" sets, notably, the Smithsonian Institution and U. S. Geological Survey. The fortunate conditions which have enabled us to make these collections are not likely to recur and the value of such material increases as the book market is cleared of documents.

We should make immediate plans for similar collections of the documents of separate States and foreign countries before it is too late. We should have official documents of engineering and public works of cities, States and nations; official documents on public health and vital statistics; on labor and the laboring classes; the reports of boards of agriculture; reports of special commissions covering many subjects from rural life to manufactures, from temperance and charities to technical education, as they touch our lines. A reference library cannot exist without official documents and research is impossible without them.

In the case of irrigation literature, a list of ditch and water companies should be made for purpose of correspondence. We should collect official information that is not now in print and probably never will be until some library collects the material for the research worker. All this document work should be pushed to a comprehensive stage so that check listing may be begun at once.

Our collection of documents is worth $10,000 at a low estimate and it has cost us very little. We are about to begin the difficult and expensive part of that work.

SCIENTIFIC TRANSACTIONS AND PERIODICALS.

We have a few good sets or parts of sets, especially in agricultural chemistry and botany, but we are without many important titles. We cannot take rank as a scientific library until we have given this class of literature more attention in English, French, German and Italian serials and periodicals.

Subscriptions to current serials and their binding costs us less than three other institutions in Colorado, but we are doing all we can do with current funds for maintenance. As for the binding, we have a great deal too much of unbound material and we should make provisions for much of it in pamphlet cases. We are now at work on the design of a new pamphlet case, a little better than anything we know now in use.

Binding costs a great deal of money and it should be faced as an inevitable expense. It costs a great deal of money to conduct any sort of good service, and good binding is an important part of library service.

CATALOGS AND BIBLIOGRAPHY.

We use a dictionary catalog of about 80,000 cards and a catalog of station literature of about 30,000 cards. We have a collection of document catalogs and the representative bibliographies.

All things considered, we have an excellent beginning, and this department of the service is growing rapidly. We have to thank our purchasing for intelligent support of this indispensable equipment.

FIRST THINGS NEEDED IN EQUIPMENT.

We need shelf room, floor space, desk and office equipment and what is generally known as "room to turn around in."

MAINTENANCE.

The librarian does not forget that the problem of the whole institution is larger than that of the library. The duty of the librarian, however, is to state his case with the library in mind.

The rate of increase in library maintenance is nearly fourfold in seven years, and, although we are behind our neighbors in maintenance, that is all a librarian can expect. We realize the difficulties in the growth of the institution and we are thankful for constant help as far as the money will go.

Because of an increase, we are enabled to keep the library open five nights each week for five months and in several other ways to make the library more and more a general service office. We are in actual need of larger maintenance in order to meet the demands made on our service.

MISCELLANEOUS.

Library instruction—Besides systematic instruction of the student body in the use of library and books, we have a few special students in the library. The instruction includes library science, library economy and library handicraft. We have supplied several librarians and assistants in Colorado and other States. The work is described in the annual catalog of the College. There should be a library school under the direction of the State Library Commission, but until that commission is provided with funds, we shall continue with some duty in the matter. The library situation in Colorado is calling for trained workers.

Correspondence and exchange, information bureau, extension work, donations, and several minor headings must be omitted from this report, but it should be noted that a large part of our donations is due to the recent system introduced by Mr. Wm. L. Post, Superintendent of Documents in Washington, who has done more for us that can be told in a brief report. Mr. Post has worked wonders for all libraries that mean business in document service. We can never give sufficient thanks to Mr. Post and to Mr. Franklin E. Brooks, who gave us our document designation.

SPECIAL COLLECTIONS.

We have now the Annie Jones collection, the Louis B. France collection, the B. O. Aylesworth collection and the Theo-

dosia Ammons memorial collection. All but the last have been noted in previous reports. The Ammons memorial was donated for the Domestic Science Department by the Colorado Federation of Woman's Clubs.

DEPARTMENT LIBRARIES.

This will require a special report, and when the time arrives this matter will prove one of the difficult problems of the College. Department libraries, department apportionments, custodianship and the best form of service for the greatest number are in a hopeless jumble of administration in the college and university libraries of the United States.

BOOKS IN THE LIBRARY.

It is not easy to make an accurate count of books in a library with so little shelving and so many books. Our actual shelf capacity measures (in the main library) about 30,000 and the floor holds several thousand more. If our material were recorded as usual in large libraries we should have a little more than 40,000 volumes, bound and unbound, but not counting pamphlets. The bound volumes in the library increase rapidly as we reduce the unbound and the pamphlets by binding. Our pamphlets have been reduced to 35,000 pieces, but will probably show an increase next year because we have no room for arrangement of pamphlets into volumes for binding.

STATISTICS,

Finances, Inventory, etc., are submitted to the Secretary and are not a part of this report.

I take this opportunity to thank those who have helped in the growth of this library. The recognition of the professional service of the librarian and of the importance of the library in the educational plan is the most gratifying event in our records for the year and will be most influential in the future of the library.

Respectfully,

JOSEPH F. DANIELS,
Librarian.

REPORT DEPARTMENT OF MATHEMATICS.

To the State Board of Agriculture:

Gentlemen—During the past year this Department has done considerably more work than is outlined in the catalog. Classes have been taught in the following subjects: Elementary Algebra, Plane Geometry, Solid Geometry, College Algebra, Plane and Spherical Trigonometry, Plane Analytics, Differential Calculus, Integral Calculus, Solid Analytics and Mathematical Drawing, Elementary Arithmetic, Commercial Arithmetic. The total number of students enrolled in these classes has been 458.

We are making a special effort this year to meet individual needs. Many worthy, hard-working students have a poor faculty for Mathematics, and in consequence either change to a course where Mathematics is not prerequisite or drop out of school. We have sought these out, and by special appointment daily have given them such suggestions and encouragement as to materially strengthen their work.

It seems to go without saying that a workable knowledge of Mathematics is the most vital feature in technical education. It has therefore been our purpose to make the Department of the utmost practical importance to both the Agriculturist and the Engineer. To this end we have striven to introduce numerous problems from practical affairs. Miss Frink is deserving of favorable mention in this regard. She has compiled some 125 problems relating to farm life, irrigation, etc., which we are teaching in the practical course in Agriculture.

Regarding my assistants I beg to say there has not been a discordant note during the year. The disposition has been constant devotion to duty. Out of the many hundreds of recitations I can not recall of a single instance in which a lesson has been missed on account of the absence of a teacher.

Permit me to remind you that since my last report five young ladies have elected to take advanced mathematics, and they have been eminently successful in their work. At the present time I am directing post-graduate work in Solid Analytics and in the History and Pedagogy of Mathematics.

Respectfully submitted to the State Board to whom I am grateful for continued courtesies.

S. L. MACDONALD,
Head of the Department.

December 1, 1908.

REPORT OF DEPARTMENT OF MECHANICAL ENGINEERING

To the State Board of Agriculture:

Gentlemen—I have the honor to submit the annual report of the Department of Mechanical Engineering.

The course in Mechanical Engineering as presented at the Colorado Agricultural College is such as is given at the best technical schools of the United States.

The instruction is intended to be thorough, and the equipment is of the very best, care being taken when obtaining apparatus that each piece shall be of the greatest usefulness for its purpose.

Colorado is forging ahead magnificently along industrial lines, and with the development of the vast natural resources within her borders new industrial enterprises are springing up everywhere, while the older ones are becoming more firmly established.

With this industrial growth comes a demand for men competent to solve the problems connected with such enterprises. Young men from the College are in many of these establishments, occupying positions of trust and responsibility.

We are trying, first, to teach the general underlying principles of engineering, then to add as much detail and special technical knowledge as a course extending over four years will permit.

We believe our methods of teaching are in conformity with the best modern practice, and while we are practicing no freak or short-cut methods, we are trying to give our students real, substantial values.

We have a larger number of older students this year than usual, and it is gratifying to note their interest and earnestness of purpose.

The various lines of study seem to articulate very well, and our young men find very little difficulty in putting to practical use the technical knowledge they have acquired while at the College.

The Course in Farriery is patronized to about the same extent as it was last year, and the young men are interested in the work.

The Short Course in Mechanic Arts has a few students who are taking the work, but it will have to be discontinued next

year as the studies in this course are taken from those of the preparatory school, and as the studies can not be given next year, these students can not be accommodated.

While we are doing well with the equipment we have, I desire to outline for your consideration some few improvements which will make for progress and add greatly to the usefulness of the Department.

The Department of Mechanical Engineering, while specifically training students for the work of the Mechanical Engineer, is, at the same time, in many of its divisions of work, training the students of several other departments of the institution. Drawing is taught to the Freshmen and Sophomores in several of the courses, steam boilers, also the several lines of shop work. This requires a large amount of room to accommodate the students in some features of the work, and we have arrived at a point where more room ought to be provided.

The drafting room, the wood room and the forge room are the places where the most pressure is felt, and I make the following suggestions as a remedy for these conditions.

Build a third story upon the north wing of the present Mechanical Engineering building in which a drafting room and class rooms may be fitted up.

Enlarge the present blacksmith shop by taking in with it the foundry room, and then build a new foundry room adjoining the present one.

To satisfy the demand in the wood room the present benches with their equipment should be doubled in number. The requisite number of benches can be put in by crowding them into the room now used as a carpenter shop.

We have no trouble in holding the interest of the students in their work, and the above changes would tend to simplify very much the arrangement of work.

Respectfully submitted,
J. W. LAWRENCE,
Professor of Mechanical Engineering.

November 15, 1908.

The State Board of Agriculture:

Gentlemen—I have the honor to submit the following report for the semi-annual period ending November 15, 1908:

The progressive instruction in infantry drill regulations, as outlined by general orders from War Department, has been carried out as far as possible; lack of a suitable rifle range and limited time allowance prevented the prescribed course in target practice. Lectures bearing upon the subject and also on field service have been given, together with theoretical and practical instruction in signaling. The report of the Military Inspector for the year 1907-8, now on file in the President's office, is the most favorable one yet received. The Battalion at present consists of thirteen (13) officers and one hundred and fifty-four (154) N. C. O's and privates, divided into four infantry companies and band. The figures show a falling off in attendance; however, the present students are larger, stronger and more capable of doing advanced work. The band is furnishing good music, and I believe that it is deserving of all possible assistance and encouragement. The medals and flag so kindly donated by Captain B. F. Rockafellow were the means of stimulating a friendly rivalry amongst the students, and in the final contest twelve cadets entered. Sergt. H. B. Scammel won the gold and Sergt. Victor Cram the silver medal. Company "B" won the flag.

Very respectfully,

H. D. HUMPHREY,
Captain U. S. Army.
Professor Military Science and Tactics.

REPORT OF DEPARTMENT OF MODERN LANGUAGES.

To the State Board of Agriculture:

Gentlemen—The work in the Modern Language Department is noticeably stronger this year, since no student lower than the sophomore class is allowed to take it. Two-year courses in both French and German are offered, and one year in Spanish. The work is obligatory for all but the Agricultural and Veterinary Departments.

It must be understood that this work is not of an academic or classical nature, that it is in harmony with the spirit of this institution, and as scientific and practical as we can make it.

In consideration of the fact that all our work is college work and that there is so much of it that I have had to have an assistant this year, I most respectfully ask for my Department and for my professorship. This is my fourth year in connection with the College (one year spent at the Universities of Berlin and Paris), and I have waited from year to year expecting this Department to be recognized by the Board. It is in no way dependent on any other Department, nor has it been for the last seven or eight years.

If you would be so kind as to give this matter your consideration, I should be most grateful.

Respectfully yours,

SARAH I. KETTLE,
Instructor in Modern Languages.

REPORT OF THE CONSERVATORY OF MUSIC.

To the State Board of Agriculture:

Gentlemen—I beg to report an enrollment of one hundred students for the past year. At present there are five teachers employed in the Department. The growth of the Conservatory has been rapid and consistent. Since September, 1908, to date, we have registered eighty-two students, an increase of thirty-two per cent. over the corresponding period of 1907.

We are greatly hampered in our work for lack of room, and respectfully ask you to investigate our needs, so that we may be in a position to take care of our increasing registration.

Respectfully submitted,

ALEXANDER EMSLIE,
Director of the Conservatory of Music.

REPORT OF THE PHYSICAL DIRECTOR.

To the State Board of Agriculture:

Gentlemen—No improvements have been made and no apparatus has been added to the Gymnasium since my last report.

I again call your attention to my report for shower baths. Good health, cleanliness and convenience make these absolutely necessary.

Since the faculty has ruled that Gymnasium is compulsory, it becomes a crime against cleanliness and common decency to force students to exercise freely without giving them the opportunity to cleanse their bodies. As it is at present there is not even a wash room. Many of our students are at rooming places where it is not possible to take a bath, which makes the need of this equipment for our Gymnasium all the more urgent.

My report last year and also two years ago called your attention to this need. Conditions are becoming more aggravated, and I trust that you will see your way clear to give this matter your prompt attention.

I will gladly confer with any committee you wish to appoint to look after this matter.

Respectfully submitted,

C. J. ROTHGEB.

REPORT OF DEPARTMENT OF PHYSICS AND ELECTRICAL ENGINEERING.

To the State Board of Agriculture:

Gentlemen—The work in Physics is being done according to the schedule of studies of the various courses. No preparatory work is offered, but a class for such work will be organized beginning with the winter term, to help those freshmen who were conditioned or failed in this subject as sub-freshmen last year.

This term we are teaching in all seven classes for a total requirement of twenty-three term hours with a total enrollment of one hundred men. The students are doing good work. They are responding to our stronger requirements for credit with an enthusiasm that is most encouraging, and strengthens the belief that students desire the best the College can give and are quite willing, nay anxious, to do their share of the work. That men do not leave an institution because the work is hard, but because it is of low standard, and that the best way to hold students in school, to make them enthusiastic in their loyalty and firm in their devotion to their alma mater, to weld them into a powerful organization for winning new students, is to set a high standard of scholarship and maintain it at any cost.

The limited laboratory quarters makes the work of instruction difficult and arduous. The hours of teaching are increased and the work of preparation and maintenance of apparatus practically doubled. Fortunately, the subject has a strong hold on the interest of the boys and they work under the increased difficulties in a very commendable manner, and show a desire to be helpful that goes far in easing the work of the instructors.

The installation of a large motor-driven fan has solved the ventilation problem. We can now keep the air sufficiently pure that it is no longer a menace to health to spend two hours daily in the laboratory. On cold days we still freeze out unless we open the window leading to the space under Mr. Hawley's office and through this rob the furnace room of its hot air and the boiler of its draft. This difficulty should be overcome as soon as the extra radiators for heat and ventilation are installed that were ordered in August. Unfortunately, the company having the contract has been unable to secure any indirect radiators and can not proceed with the work which embraces the installation of an indirect radiator outside of and above each of four windows of the

laboratory. These will be boxed in so that air can be drawn through them and into the room while classes are in session. Provision is made that each radiator can be shut off not only to prevent freezing at night, but also to relieve the strain on the boiler while the building is being heated up in the morning.

The change in the course of study, particularly in Horticulture and all Engineering courses, has increased the need of more apparatus. Before this change most of the work was given to preparatory classes, little was offered above the freshman year. The laboratory was fitted for this grade of work, and much of the apparatus is not of the kind needed for college classes and can no longer be used. While this difficulty was foreseen and partially provided for, the funds available have not been sufficient for the needed equipment; through the desire also to help economize when the institution was curtailing expenses, the coming need has not been strongly emphasized. More equipment is imperative if College standards are to be maintained. To meet the necessity of training students for radically different lines of work, the equipment must necessarily be varied and extensive, and the purchasing of this should not be by single piece and spasmodically as heretofore, an expensive and uncertain method, but a certain known sum should be available each year for new equipment. Knowing that a fixed sum was available, the head of the department could plan his purchases systematically to best fit its needs, could take advantage of special bargains and get the more liberal discounts of large orders, particularly imported apparatus. I commend the needs of the department and this plan of apportioning funds to your consideration.

ELECTRICAL ENGINEERING.

The growth of the course in Electrical Engineering, and the interest and enthusiasm shown by the students, prove the wisdom of your action in reinstating the course in the curriculum of the College, and abundantly justify the expense that has been necessary so far. The records show an enrollment of ten juniors out of a total of twenty-four and of fourteen sophomores out of a total of thirty-three in all engineering courses. All but three sophomores of last year returned; one of these will enter school this winter term, and another is earning money to return next year. We are teaching in all two classes for a credit requirement of ten term hours and have a total enrollment of twenty-four. The Mechanical Laboratory has been partially fitted up for work in electrical measurements. The work of teaching is heavy; in part because all apparatus is kept in the Physical Laboratory and must be carried back and forth; in part on account of the unfinished condition of the installation. The students are making the best of the unfavorable conditions and are helping to whip things into shape.

The new equipment installed last summer is giving excellent service and is proving very well adapted for the purpose intended.

As much as possible of this work was done by student labor and furnished good experience. On account of an unforeseen delay in getting the last machine, the work is not completed and it has not been possible, as yet, to use electric power in the shops. There is therefore no basis for comparative cost of steam and electric power, but we are confident that the latter will prove enough cheaper to save the cost of its installation inside of five years. The cost of power for electrical measurements has not exceeded 60 cents per month so far.

The work of this course is so promising and its field of usefulness is so large that it deserves your earnest consideration. It has started out without a building and with meager equipment; the boys who are placing their faith and hope in the training it is to give are entitled to all the help you can bestow. If you consider the money spent per student in Physics and Electrical Engineering last year and keep in mind also the high cost of apparatus, I believe you will agree that our requests have been moderate and that we are entitled to a more liberal allowance. We are competing with schools where Electrical Engineering has been long established, where both laboratory and testing rooms are well equipped. To get our share of students, it will be necessary not only to put the work of instruction on a par with the best technical schools, but also to furnish the equipment that makes this possible. I believe you will agree with me that the money spent so far makes a creditable showing. At least double as much should be available for this year if full preparation is to be made for the entire work of the course next year.

Two of us, with the help of two student helpers and a student mechanician, are carrying all the work of teaching and general supervision. Mr. William E. Bracket, our able assistant, last year resigned in August to accept a call from the State University, and Mr. Fred G. Person, a graduate of Colorado University, and for three years principal of the Montrose County High School, took his place in the department. Mr. Person is proving himself a strong man in the work and is carrying his share of it in a very satisfactory manner.

The regular requirements of the curriculum will be so heavy another year that another teacher will be needed in the department; serving as it does each of the four years of College work in some of the several courses, the demands made upon it are severe. The training in Physics is fundamental and must be good. The work in Electrical Engineering must be high class if your plans for it are to come true. I trust you will consider this need of more instructors at your mid-winter meeting, so we can begin an early search for a strong, energetic, well-trained young man, preferably a graduate from one of the great technical schools of the East, for associate professor in Electrical Engineering next year.

Respectfully submitted,

CHARLES A. LORY,
Professor of Physics and Electrical Engineering.

SUPPLEMENTAL REPORT.

Department of Electrical Supplies.

The Department of Physics and Electrical Engineering, with the help of student labor, is taking care of all electrical work, new wiring and repair, on the Campus. Although the system has not been worked up to the efficiency we hope to get, in many respects it is far more satisfactory than the old method of contract service. Its most commendable feature is the chance it offers the Electrical Engineering students for practical experience. A better system of keeping check on the supply room is being worked out; the difficulties of this problem would be much less if we had better storage room. Our method of buying supplies also needs improvement. The cost on small orders of electrical supplies is high, practically no discount being offered. On large quantities the discount may reach 40 per cent. It should be possible for the College to make some arrangement with a local supply firm whereby we could get supplies in small quantities as needed, and yet, on account of the volume of business for the year be entitled to very nearly wholesale-order discount rates.

A number of much-needed repairs to our transmission lines were made last summer. All the power wires in the Mechanical Engineering Building were installed in iron conduits, and the distribution system as a whole was overhauled. Nearly all the buildings are still without main service switches and adequate fuse protection. These should be provided as soon as possible. I recommend for your consideration the installation of incandescent lights at the portals of all the buildings, especially those of the Main, Civil Engineering, Domestic Science and Chemical Buildings, and at the fountain for illuminating the Campus. This plan will be cheaper than the use of arc lamps, and will serve the purpose admirably. The lights would be turned out by the night watchman at any desired hour.

I recommend for your consideration also the installation of metallic filament lamps in all sockets not within easy reach of the students. Their use would increase our illumination and decrease the cost of energy. The use of clear lamps in the Chapel is very trying on the eyes, and spoils what otherwise is a very pleasant effect; frosted lamps only should be used in this room, and if Tungsten lamps were used the cost of energy per candle hour would show a decrease of fully 40 per cent., or a decrease of over 20 per cent. if Tantulum lamps were used. Our present method of exchanging lamps, i. e., free renewals with the power

station, is neither satisfactory nor advantageous. We are forced to use a 115-volt lamp on 104-volt circuits, which means poor illumination, and the low efficiency lamps furnished by the Company means high meter bills. Conditions are such that we will soon be forced to our former plan of buying our own lamps. The high cost of the new metallic filament lamps will prevent their use in sockets accessible to the students. We have had a great many lamps stolen this fall, many students apparently believing it legitimate to replenish their incandescent lamp stock at the College. The trouble has become so bad in some buildings that the use of a special lock socket is advisable. In sockets not easily accessible the new high efficiency lamp should be used, because, in spite of first cost the saving of energy their use makes possible will warrant their installation.

Respectfully submitted,

CHARLES A. LORY,
Professor of Physics and Electrical Engineering.

REPORT OF THE DEPARTMENT OF VETERINARY SCIENCE.

To the State Board of Agriculture:

Gentlemen—In my report of one year ago this prophetic statement was made: "In one particular this course of study (Veterinary) is to be looked upon as entirely different from others. In the ordinary vocations of life, a question is seldom asked as to a man's preparation for his work, whether within college walls or otherwise; it simply remains for him to prove what he can do. In the profession of medicine it is quite different, for here he is judged by his co-workers uncompromisingly according to the reputation of the school from which he received his degree.

"This department has now launched out as a full-fledged veterinary college, and we shall need to look to our educational standing that we may compare favorably with older schools. I fully appreciate the moral responsibility devolving upon us to see that our graduates are eligible to employment in the Bureau of Animal Industry and to membership in the American Association of Veterinarians.

"The American Association have their eyes upon us, and they carefully investigate every school seeking recognition, and have black-listed several. The graduates from such schools are without standing. They are not employed by the Department of Agriculture, neither are they granted certificates to practice in many of the states.

"To rank among the list of recognized veterinary colleges, we must have at least three veterinarians on the regular faculty who are eligible to membership in the American Association. The curriculum must be satisfactory and the subjects therein named must be actually taught with a degree of efficiency that will be beyond question. And lastly, the equipment must be ample, and a large clinic is indispensable."

Within a few months after this report was made, the Department of Agriculture appointed a committee of five to investigate the Veterinary Schools of America. The committee visited us unexpectedly, and before we had scarcely opened our doors five months as a full-fledged veterinary school. We were placed in Class C, which would make our graduates, if we had any, ineligible to the Civil Service Examination, and which in substance practically black-listed us among Veterinary Colleges.

The committee, after making their report, addressed the following letter, indicating where we had failed:

EXHIBIT "K."

"COPY OF REPORT ON THE VETERINARY DEPARTMENT COLORADO STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS, BY THE COMMITTEE ON VETERINARY EDUCATION."

"After having visited the Colorado State College of Agriculture and the Mechanic Arts, Department of Veterinary Science, on March 13, 1908, and obtained all available information, the following are submitted as the most important points at which that institution must be strengthened in order to come up to the minimum standard of requirements deemed essential by this committee:

"1. The faculty of this institution has on it an insufficient number of veterinarians teaching major subjects. At the time of our visit instruction was being given to only first and second year students. It is the opinion of the committee that the faculty as at present constituted lacks veterinarians who have had adequate training and experience in veterinary lines. There are at present only three veterinarians on the faculty giving sufficient time to college work, and two of these—I. E. Newsom and H. E. Kingman—have not had the necessary veterinary college training to render them eligible to membership in the American Medical Veterinary Association or to the civil service examination for employment in the United States Department of Agriculture."

"2. The buildings and equipment for offices, bacteriological laboratory, and class rooms are inadequate to the needs of the institution. It also appears that the material available for clinical instruction is insufficient."

Previous to the investigation made by the Department of Agriculture, we were trying to line up to the standard set by the American Veterinary Medical Association. We had three veterinarians on the teaching staff and otherwise were trying to come up to their standard. It could scarcely be expected that within a few months after opening our doors that we would be fully equipped and up to the standard of older schools.

The Department of Agriculture has now set a higher standard for us and which we are obliged to live up to or be discredited everywhere.

Their report, Recommendation No. 10, reads: "That there shall be at least five qualified veterinarians on the faculty of every veterinary college, each of whom shall have had not less than three years' experience in teaching or in practicing veterinary science subsequent to graduation from a veterinary college."

Recommendation No. 12: "That five veterinarians on the faculty of each veterinary college shall have charge of and teach the following major subjects: (1) Anatomy, (2) Pathology, (3) Practice of Comparative Medicine, (4) Surgery, and (5) Materia Medica, or Physiology, as the respective colleges may elect."

Recommendation No. 5 is a course of study given as a minimum for veterinary colleges, and also indicates how these subjects shall be taught and the minimum number of hours that shall be devoted to each subject.

As a whole the requirements are very exacting, but in no respect unreasonable, and are, we must admit, fully in accord with the up-to-date idea of veterinary education in America.

We have been bending every effort to meet these requirements before the termination of our period of probation, which is June 10, 1909.

Dr. I. E. Newsom and Dr. H. E. Kingman were perfectly competent and efficient in every way, but were caught by a technicality and they immediately resigned to continue their work in the Kansas City Veterinary College.

There is no change in our "buildings and equipments for offices." A temporary shift has been made to meet their criticism of our bacteriological laboratory by using a small room in the horticultural building. As to their criticism that our "class rooms are inadequate to the needs of the institution," I can only say that it is true. We have one new class room, but the largest one will scarcely hold the forty-five students registered for the work.

I trust that we may be permitted to ask the incoming Legislature for a special appropriation for at least one wing of a veterinary building. I feel sure that we will be able to meet every criticism this year, save the one respecting our buildings, class rooms and laboratories.

Their next criticism: "It also appears that the material available for clinical instruction is insufficient." This objection has been entirely overcome. We have exercised every effort to enlarge upon the practical work and have been rewarded with a clinic which will successfully refute any objections in this respect in the future.

OUR TEACHING STAFF.

Dr. B. F. Kaupp is a leader in the veterinary profession of America. He is the author of a standard text-book on parasites and a teacher and writer of national repute.

Dr. C. L. Barnes is a graduate of Cornell University, and is an experienced teacher and practitioner. He has been generous enough to place in the hospital for use, temporarily, several hundred dollars' worth of veterinary instruments.

Dr. Robert Bird, of Greeley, has kindly consented to come over twice a week and help us. He will help us, however, only

during the winter term of this year. At the beginning of the spring term we shall need to make some other arrangements.

Dr. F. W. Culver, of Longmont, comes up twice a week to lecture. These last two men are only temporary and will need to be replaced by permanent instructors to make the required five teaching major subjects.

Here is a matter that is causing me much concern; we are required to have five Veterinarians in charge of and teaching five major subjects, and two of these men, Drs. Bird and Culver can only help us until the spring term. There are no other local Veterinarians qualified to take up the work; besides, there would not be much difference in the expense of employing two men regularly, and several men from the outside who can only give us three or four hours a week, and are always more or less inefficient and at best uncertain.

Under the present regimen, the three classes in the regular Veterinary Course, the two in the practical Short Courses, and two in Farriery, require eighty-five hours per week of actual teaching, to be done by Dr. Kaupp, Dr. Barnes and myself. This amount of labor makes good work prohibitive if continued long, and portends an early departure to the world beyond. I am struggling with these difficult problems, trying to build up a department which will be a credit to the College and the State.

MICROSCOPES.

Twenty-five more microscopes are absolutely essential to the work in our several Veterinary Laboratories next year. By ordering these microscopes about March 1, from Germany, they could be gotten here by September and save us three hundred dollars.

TO SECURE RE-RATING.

Recommendation No. 17 reads as follows: "That these Colleges not now in Class A shall be put in that class at such time as they shall submit sufficient evidence to convince the Department of Agriculture that they are fully and faithfully complying with the minimum standard of requirements indicated in this report."

In compliance with this recommendation we have already forwarded to Washington a full and complete report of our work and now confidently await their will and pleasure.

PATHOLOGY MUSEUM.

We have already gotten together a Pathology Museum of which we are proud. It not only is an appropriate acquisition to a school of this kind, but greatly facilitates the teaching and represents an intrinsic value of possibly five hundred dollars.

VACCINE.

We have undertaken the manufacture of black leg vaccine, and, in conjunction with the Experiment Station, hog cholera serum. We now have the vaccine ready for distribution. Its manufacture involves much painstaking labor, but does not represent much money invested. We can make a vaccine in our laboratories which will be of superior quality, and sell it to the farmers and stockmen of Colorado at a price that will be a great saving to them and at the same time render a substantial support to the Veterinary Department, if you will authorize its being so used. He now have about two thousand dollars' worth ready for distribution.

HOSPITAL.

The practical work in Veterinary education is indispensable. At the hospital we have worked up a good clinic and done it in the only way that it could be done, by going out and working for it. We charge a reasonable fee for some of the cases treated and this goes a long way toward paying the expense of operating it.

PROSPECTUS.

While I am having my difficulties in getting this Department on a secure footing, yet I feel rewarded in the evidence of appreciation by all concerned and especially in the loyalty of the student body.

Last fall, while we were discredited as a Veterinary school and the institution in other respects was undergoing a turmoil, the young men that were with us the year before were loyal enough and had faith enough in us to come back and cast their lot with us. We now have forty-five registered, and next year, if we succeed in getting placed in Class A and are properly supported, we may confidently expect fully one hundred.

The Kansas City Veterinary College has over five hundred students registered in Veterinary Science and each one of them pays an annual tuition of one hundred dollars. Veterinary education is popular now, and we may expect to see this Department grow commensurate with the popular wave and with the support which it receives.

Respectfully submitted,

GEORGE H. GLOVER.

REPORT OF THE YOUNG MEN'S CHRISTIAN ASSOCIATION.

To the State Board of Agriculture:

Gentlemen—This report includes the principal activities of the Association from the close of last school year to the present date.

SUMMER WORK.

Sixteen men attended the Student Conference which was held at Cascade, Colorado, from June 12th to 22d. This number included two faculty men and the retiring and present secretaries. The present secretary attended, also, the Student Secretaries' Conference at Geneva, Wisconsin, June 23d to July 6th.

NEW STUDENT WORK.

Letters of welcome and information, concerning both the Association and College, were sent to all prospective students. A complete list of the rooms and boarding places was secured and the greater part of both the old and new students were aided in getting located. During the opening day, the trains were met by men with badges from the Association and all newcomers were taken in charge and helped in every way possible.

SOCIAL DEPARTMENT.

The Association recognizes the need of a social life that will reach *all* the students, and they have carried out the following plans thus far:

The "Stag Social" (Sept. 11th) was held the first Friday night and almost every man in College attended. "Stunts" were so arranged that all had a full evening of fun.

The "Joint Reception" (Sept. 18th) was given in conjunction with the Young Women's Christian Association, and was attended by about two hundred people.

Bible-class parties have been held on different Friday evenings in the Rest room. Most of the men and women in the classes have been entertained in these small parties, and it shall be the aim of the Associations to provide social life for those who most need it throughout the year.

BIBLE STUDY.

Two courss are being offered this year by the Association in Bible study, "Men of the Old Testament" (Willman) and

"The Life of Christ" (Murrey). The student leaders are in a Normal Training Class led by the Secretary. Sixty-five men are now enrolled in these classes.

RELIGIOUS MEETINGS.

The plans of the Religious Meetings have been changed this year. The regular Sunday meeting has been held as usual, but due to the chapel hour being abolished, the mid-week meeting is held with the Young Women's Christian Association each Tuesday evening at 6:45 for three-quarters of an hour. The mid-week meeting is strictly a student meeting, while the Sunday meetings are addressed by the ministers and men from the outside.

Some special meetings have been held, two of which I shall especially mention. Dr. Winfield S. Hall, dean of Northwestern University, addressed 350 men with his noted lecture on "Reproduction and Sexual Hygiene," and "Dad" Elliott, an international traveling secretary, held a three days' campaign here the first of November.

EMPLOYMENT.

Some men have been placed in permanent positions and a large number have been given odd jobs to do. The first month of school there was about $50.00 worth of work obtained for the students through the Association employment bureau.

PRACTICAL COURSE STUDENTS.

Letters were sent to all the Practical Course Students, and they were cared for the same as the Regular Students when they came. They were aided in securing room and board, a place to get their washing done and all the necessities that were required; in addition they were given special attention and advice as to the different activities of college life.

FINANCES.

The income thus far this year has been $388.00. This includes the balance on hand, subscriptions paid, convention funds repaid, mission pledges and some small items. The expenditure has been $195.81, leaving a balance on hand of $192.19.

It is estimated, by careful figuring, that we shall have to raise at least $175.00 more than has been pledged to meet the current expenses this year.

ADMINISTRATION.

The Association office has been supplied with good magazines and literature and it is open most of the time for the stu-

dents to read and study in. A number of the students are making use of it.

The vacancies in the Cabinet have been filled and the machinery of the Association is now working very well.

The Secretary wishes to express his appreciation of the hearty co-operation of the State Board in so materially aiding the Association in making it possible for this work to be carried on.

Respectfully submitted,

WARD E. HALL,
General Secretary.

November 15, 1908.

REPORT OF THE DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY.

To the State Board of Agriculture.

Gentlemen—I have the honor to present the following report from the Department of Zoology and Entomology for the year just closing.

The personnel of the department has not changed during the past year.

Professor S. Arthur Johnson is associate professor in the Department. Mr. L. C. Bragg looks after the College Museum and gives considerable of his time to the Entomological work of the Department. Miss Palmer does most of her work for the Experiment Station and also does some teaching and some breeding cage work and keeping of records.

On account of my devoting more time to research and other Experiment Station work I find it necessary to turn the teaching over quite largely to Professor Johnson, who has proven himself very successful as an instructor of college students.

During the past year I have attended six Short Courses of one week each, and a considerable number of farmers' meetings of one day each, and given addresses, chiefly along the line of economic entomology.

The utmost harmony has prevailed in the work of the Department throughout the year.

There have been a few donations to the College Museum during the year, but on account of the lack of money to make any purchases either of speciments or needed cases, the museum is practically in the same condition that it was one year ago.

Appended hereto is an invoice of College property cared for in this Department.

Respectfully submitted,

C. P. GILLETTE.

Fort Collins, Colo., October 30, 1908.

AUDIT OF

State Agricultural College

FROM

DECEMBER 1, 1906, TO NOVEMBER 30, 1907

AND

DECEMBER 1, 1907, TO NOVEMBER 30, 1908

Hon. B. F. Rockafellow,

President State Board of Agriculture,

Fort Collins, Colorado.

Dear Sir—Pursuant to the instructions of your Executive Committee, we have made an audit of the books and accounts of the State Agricultural College, from December 1, 1906, to November 30, 1907, inclusive, and herewith submit our findings:

SECRETARY'S CASH.

All collections have been properly accounted for and paid over to the State and College Treasurers.

DISBURSEMENTS.

All disbursements are evidenced by duly authenticated bills, and all vouchers are properly approved by the Finance Committee.

COLLEGE TREASURER.

We verified the balances shown as in the hands of the College Treasurer as of date November 27, before issuance of November warrants, at which time the balance, per books, was—

		$29,918.56
Warrants outstanding		
Tax Fund, No. 154	11.15	
Tax Fund, No. 921	50.00	
Tax Fund, No. 1012	89.09	
Experiment Station Appropriation, No. 1	62.50	
Experiment Station Appropriation, No. 18	6.52	
Bank balance		$30,137.82

STATEMENTS.

The following statements exhibit the transactions of the past year:

SECRETARY'S CASH ACCOUNT.

RECEIPTS.

Secretary's Office, Sales	$ 1.50	
Agronomy Division, Sales	20.00	
Animal Husbandry Division, Sales	7,422.27	
Farm Division, Sales	77.30	
Farm Mechanics Division, Sales	33.90	
Botany and Horticultural Division, Sales	127.95	
Chemical Division, Sales	100.00	
Domestic Science Department, Sales	24.86	
Library	32.80	
Insurance, Return Premium	5.40	
Transfers, College Funds	9,285.73	
Text Book Department, Sales	2,795.03	
Entrance Fees	330.00	
Commercial Department	60.00	
Agronomy Section	183.71	
Animal Investigation Section	1,568.87	
Veterinary Section	45.85	
Western Slope Fruit Investigation	375.00	
Transfers, Experiment Station	5,038.52	
Government Horse Breeding	170.00	
Delta County Fruit Investigation	700.00	
Horticultural Section	76.13	
COLLEGE SPECIAL FUND—		
Paid State Treasurer		$ 2,655.14
Paid College Treasurer		16,564.88
EXPERIMENT STATION, SPECIAL FUND—		
Paid College Treasurer		9,202.30
HATCH FUND—		
Paid College Treasurer		52.50
	$28,474.82	$28,474.82

RECEIPTS AND DISBURSEMENTS.

	Balance Dec. 1, 1906.	Receipts	Transfers to	Transfers from	Disbursements	Balance State Treasury	Balance College Treasury
Agricultural College							
Tax Fund	$ 1,994.55	$ 69,780.05	$ 7,400.00	$ 2,366.56	$ 89,130.22	$ 221.07	$16,532.35
Land Income Fund	358.05	8,188.04	.....	.....	5,422.66	963.96	2,159.47
Special Fund	3,210.80	9,934.29	9,285.73	.....	15,690.25	.....	5,240.57
*Secretary's Revolving Fund	.....	.....	.....	.....	.....	.....	1,500.00
Mechanical Arts (U. S.)	8,854.56	30,000.00	.....	.....	24,100.17	.....	14,754.39
Purchase Fund	.....	13,585.25	.....	7,400.00	6,185.25	.....	.....
Appropriation, Farmers' Institute	.....	10,000.00	.....	2,724.83	712.36	5,000.00	1,562.81
Appropriation, Land and Water	.....	7,500.00	.....	.....	7,500.00	3,750.00	3,750.00
Appropriation, Irrigation Building	.....	16,633.84	.....	4,194.34	.....	.....	12,439.50
Experiment Station—							
Hatch Fund	286.47	15,000.00	52.50	.....	12,785.00	.....	1,981.03
Adams Fund	455.26	5,250.00	.....	.....	8,605.81	.....	2,900.55
Special Fund	1,065.84	4,216.28	4,986.02	52.50	9,147.33	.....	1,068.31
Appropriation, Animal Investigation	.....	6,000.00	.....	545.21	1,996.36	3,000.00	458.43
Appropriation, Plant Industry	.....	4,000.00	.....	1,292.03	339.90	2,000.00	368.07
Appropriation, Grain House	.....	2,000.00	.....	.....	.....	1,000.00	1,000.00
Appropriation, Farm Mechanics	.....	2,000.00	.....	.....	.....	1,000.00	1,000.00

Appropriation, Veterinary	.....	500.00	.....	172.54	67.50	250.00	9.96
Appropriation, Fruit Investigation	.....	8,000.00	.....	2,969.74	423.12	4,000.00	607.14
Appropriation, Horse Investigation	.....	5,000.00	.....	6.50	473.23	2,500.00	2,020.27
		$11,663.49	$217,587.75	$21,724.25	$21,724.25	$182,579.16	$23,685.03	$22,987.05

*In Secretary's hands.

DISBURSEMENTS, COLLEGE FUNDS.

Agricultural Department—	
General Division	$ 2,855.26
Agronomy	1,156.94
Animal Husbandry	7,933.17
Farm	7,537.65
Farmers' Institute	5,316.04
Farm Mechanics	619.55
Advertising	2,820.39
Botany and Horticultural Department	1,790.29
Bookkeeping and Farm Accounts	34.58
Chemical Department	181.88
Civil and Irrigation Engineering	1,093.28
Constitutional History and Irrigation Law	2.75
College Campus	2,308.64
Current Expense	2,389.28
Domestic Science	931.24
Firemen and Janitors	4,161.78
Fuel and Lights	4,626.42
Furniture and Fixtures	849.43
Girls' Dormitory	731.00
General Repairs	1,262.34
History and Literature	36.87
Insurance	1,389.75
Library	2,081.57
Mathematical Department	44.85
Mechanical Department	1,661.71
Military	478.14
Music Department	75.83
President's Office	854.70
Physical Training Department	8.35
Physics Department	996.88
Permanent Improvements	18,223.37
Quarterly Bulletins and Reports	1,335.76
Rhetoric and Composition	58.20
Salary	65,993.93
Secretary's Office	673.87
State Board of Agriculture	1,358.20

DISBURSEMENTS, COLLEGE FUNDS—Concluded.

Student Labor	3,421.19	
Text-book Department	389.99	
Veterinary Science Department	511.22	
Zoology and Entomological Department	544.62	
Total		$148,740.91

DISBURSEMENTS, EXPERIMENT STATION.

Agricultural Section	$ 69.55	
Agronomy	1,753.41	
Animal Investigation	6,394.64	
Arkansas Valley Field Agent	63.56	
Bulletins and Report	2,004.22	
Chemical Section	598.38	
Director and General	1,054.68	
Delta County Fruit Investigation	387.46	
Entomological Section	645.47	
Fruit Investigation	423.12	
Horticultural Section	809.65	
Horse Investigation	473.23	
Irrigation Section	765.34	
Library	671.59	
Plant Industry	339.90	
Salary	15,186.16	
Veterinary Section	285.89	
Western Slope Fruit Investigation	1,912.00	
Total		$33,888.25

GENERAL COMMENTS

BOOKS AND RECORDS.

Our recommendations of last year have been carried out, and the books consolidated into two Voucher Records, one Journal and one Ledger.

DISTRIBUTION

Has been made in accordance with our former recommendations.

CASH DISBURSEMENTS.

The Secretary has now been provided with a Revolving Fund to be used in making petty cash payments, as recommended.

OFFICE METHODS

Have been much improved and the labor decreased, by drawing all funds from the State Treasurer in bulk and making disbursements through the College Treasurer only; thus avoiding the unnecessary duplication of vouchers.

BILLS AND REQUISITIONS.

The practice still obtains, in many instances, of purchasing goods first and obtaining requisition later.

STUDENT LABOR.

We renew our recommendation that these items be paid on a regular form of Pay Roll, by the Secretary, one voucher to be made monthly for the total.

CERTIFICATE.

We have made an audit of the books of The State Agricultural College, from December 1, 1906, to November 30, 1907, inclusive; and in accordance therewith we certify that the foregoing statements correctly represent the transactions for the period named.

THE CONTINENTAL AUDIT COMPANY,

(SEAL) E. F. ANTHONY,

E. F. ARTHUR, Secretary.

Dated December 4, 1907.

AUDIT STATE AGRICULTURAL COLLEGE.

December 1, 1907, to November 30, 1908.

HON. B. F. ROCKAFELLOW,

President State Board of Agriculture,

Fort Collins, Colorado:

Dear Sir—Pursuant to the instructions of your Executive Committee, we have made an audit of the books and accounts of the State Agricultural College from December 1, 1907, to November 30, 1908, inclusive, and herewith submit our findings.

SECRETARY'S CASH.

All collections have been properly accounted for and paid over to the College Treasurer.

DISBURSEMENTS.

All disbursements are evidenced by duly authenticated bills, and all vouchers are properly approved by the Finance Committee.

COLLEGE TREASURER.

We verified the balances shown as in the hands of the college treasurer, as of date November 30, 1908, at which time the balance, per books, was $37,133.66

Warrants outstanding—

Tax fund	No. 2505	80.00
Tax fund	No. 2570	2.00
College special	No. 265	75.00
Experiment station appropriation.....	No. 293	14.00
Bank balance		$37,304.66

STATEMENTS.

The following statements exhibit the transactions of t
past year:

SECRETARY'S CASH ACCOUNT.

RECEIPTS.

Agronomy Division	$ 10.23	
Animal Husbandry	4,527.27	
Farm Division	438.12	
Farm Mechanics	9.25	
General Agriculture	67.15	
Farmers' Institute	2,424.00	
Botany and Horticultural Department	53.70	
Chemical Department	238.54	
Civil and Irrigation Engineering	393.35	
Domestic Science	26.38	
Library	49.73	
Mechanical Department	38.25	
Military Department	3.00	
Physics	86.34	
Veterinary	59.59	
College Campus	3.55	
Girls' Dormitory	64.54	
Text-book Department	83.40	
Entrance Fees	569.70	
Miscellaneous Sales	34.00	
Agronomy Division	491.39	
Animal Investigation Division	7,021.13	
Chemical Section	9.20	
Horticultural Section	121.69	
Fruit Investigation	35.00	
Plant Industry	28.30	
Horse Investigation	524.20	
Delta County Fruit Investigation	100.00	
Government Horse Breeding	5.00	
Transfer from Appropriation	6,710.62	

DISBURSEMENTS.

College Special Fund—		
Paid College Treasurer		$ 9,180.
Experimental Special Fund—		
Paid College Treasurer		15,046.
	$24,226.62	$24,226.

RECEIPTS AND DISBURSEMENTS.

	Balance Dec. 1, 1907						Balance Nov. 30, 1908	
	State Treasurer	College Treasurer	Receipts	Transfers To	Transfers From	Disbursements	State Treasurer	College Treasurer
Agricultural College—								
Tax Fund	$ 221.07	$16,532.35	$ 72,578.34	.....	.....	$ 80,522.31	$ 1,299.41	$25,554.66
Land Income Fund	963.96	2,159.47	11,497.40	.....	.....	14,116.26	461.36	43.21
Special Fund	.....	5,240.57	9,180.09	.....	.....	14,319.34	.....	101.32
*Secretary's Revolving Fund	.....	1,500.00	.....	.....	.....	.....	.....	1,500.00
Mechanical Arts (U. S.)	.....	14,754.39	35,000.00	.....	.....	29,349.90	.....	20,404.49
Appropriation, Farmers' Institute	5,000.00	1,562.81	.....	.....	.....	6,562.81	.....	.....
Appropriation, Land and Water	3,750.00	3,750.00	.....	.....	.....	.....	.....	.....
Appropriation, Irrigation Building	.....	12,439.50	.....	.....	.....	12,439.50	.....	.....
Experiment Station—								
Hatch Fund	.....	1,981.03	15,000.00	.....	.....	15,005.49	.....	1,975.54
Adams Fund	.....	2,900.75	14,256.22	.....	.....	9,956.83	.....	1,399.84
Special Fund	.....	1,068.31	8,335.91	$ 6,710.62	.....	5,219.82	.....	10,895.02
Appropriation, Animal Investigation	3,000.00	458.43	.....	.....	$ 1,816.74	1,641.69	.....	.....
Appropriation, Plant Industry	2,000.00	368.07	.....	.....	739.72	1,628.35	.....	.....
Appropriation, Grain House	1,000.00	1,000.00	.....	.....	.....	2,000.00	.....	.....
Appropriation, Farm Mechanics	1,000.00	1,000.00	.....	.....	643.19	1,356.81	.....	.....
Appropriation, Veterinary	250.00	9.96	.....	.....	113.98	145.98	.....	.....

RECEIPTS AND DISBURSEMENTS—Concluded.

	Balance Dec. 1, 1907						Balance Nov. 30, 1908	
	State Treasurer	College Treasurer	Receipts	Transfers To	Transfers From	Disbursements	State Treasurer	College Treasurer
Appropriation, Fruit Investigation	4,000.00	607.14	.....	.....	1,574.12	3,033.02	.....	.....
Appropriation, Horse Investigation	2,500.00	2,020.27	.....	.....	1,822.87	2,697.40	.....	.....
Totals	$23,685.03	$22,987.05	$165,847.96	$ 6,710.62	$ 6,710.62	$199,994.51	$ 1,760.77	$10,764.76

*In Secretary's hands.

DISBURSEMENTS, COLLEGE FUNDS.

gricultural Department—

General Division	$ 1,877.97
Agronomy	979.15
Animal Husbandry	7,725.58
Farm	8,901.09
Farmers' Institute	8,246.63
Farm Mechanics	361.92
dvertising	3,062.46
otany and Horticultural Department	2,415.66
hemical Department	458.57
vil and Irrigation Engineering	790.83
onstitutional History and Irrigation Law	69.60
ollege Campus	1,368.06
urrent Expense	2,434.96
omestic Science	753.63
remen and Janitors	4,227.32
uel and Lights	4,398.07
rniture and Fixtures	797.83
rls' Dormitory	366.00
eneral Repairs	2,762.68
istory and Literature	26.57
surance	315.00
rigation Building	12,439.50
brary	1,452.50
athematical Department	13.37
echanical Department	1,189.55
ilitary	186.68
usic Department	219.13
esident's Office	677.78
ysical Training Department	28.35
ysics Department	1,256.77
rmanent Improvements	2,016.35
uarterly Bulletins and Reports	1,347.80
hetoric and Composition	45.47
lary	75,526.20
cretary's Office	458.57
ate Board of Agriculture	1,578.23
udent Labor	4,027.46

DISBURSEMENTS, COLLEGE FUNDS—Concluded.

Text Book Department	250.00
Veterinary Science Department	967.60
Water Assessments	1,198.44
Zoology and Entomological Department	90.79
	$157,310

DISBURSEMENTS, EXPERIMENT STATION.

Agronomy	$ 668.74
Animal Investigation	3,725.93
Arkansas Valley Field Agent	184.19
Bulletins and Reports	3,290.41
Buildings	450.00
Chemical Section	799.82
Director and General	977.71
Delta County Fruit Investigation	417.57
Entomological Section	683.32
Farm Mechanics	1,375.72
Fruit Investigation	3,354.28
Grain House	2,000.00
Horticultural Section	2,730.11
Horse Investigation	3,004.28
Irrigation Section	915.37
Library	123.20
Plant Industry	1,722.48
Salary	16,034.88
Veterinary Section	226.38
	$ 42,68

CERTIFICATE.

We have made an audit of the books of the State Agric tural College, from December 1, 1907, to November 30, 19 inclusive; and in accordance therewith, we certify that the fo going statements correctly represent the transactions for t period named.

THE CONTINENTAL AUDIT COMPANY,
C. F. ARTHUR,
E. F. ANTHONY, Secretary

(SEAL.)
Dated December 7, 1908.

THE STATE AGRICULTURAL COLLEGE
OF COLORADO

TWENTY-FIRST ANNUAL REPORT

OF

THE AGRICULTURAL EXPERIMENT STATION

FOR

1908

THE AGRICULTURAL EXPERIMENT STATION.

FORT COLLINS, COLORADO.

THE STATE BOARD OF AGRICULTURE.

	Term Expires.
ON. J. L. CHATFIELD, Gypsum	1909
ON. B. U. DYE, Rocky Ford	1909
ON. B. F. ROCKAFELLOW, *President,* Canon City	1911
ON. E. H. GRUBB, Carbondale	1911
ON. R. W. CORWIN, Pueblo	1913
ON. A. A. EDWARDS, Fort Collins	1913
ON. F. E. BROOKS, Colorado Springs	1915
ON. J. L. BRUSH, Greeley	1915

OVERNOR HENRY A. BUCHTEL
ESIDENT BARTON O. AYLESWORTH } *ex-officio.*

M. HAWLEY, *Secretary.* CHARLES SHELDON, *Treasurer.*

EXECUTIVE COMMITTEE IN CHARGE.

F. ROCKAFELLOW, *Chairman.* A. A. EDWARDS.

B. U. DYE.

STATION STAFF.

L. G. CARPENTER, M. S., *Director*.....Irrigation Engineer
C. P. GILLETTE, M. S.....Entomologist
W. P. HEADDEN, A. M., PH. D.....Chemist
WENDELL PADDOCK, M. S.....Horticulturist
W. L. CARLYLE, M. S.*.....Agriculturist
G. H. GLOVER, M. S., D. V. M.....Veterinarian
————†.....Agriculturist
W. H. OLIN, M. S.*.....Agronomist
W. G. SACKETT, B. S.**.....Bacteriologist
R. E. TRIMBLE, B. S.....Assistant Irrigation Engineer
F. C. ALFORD, M. S.....Assistant Chemist
EARL DOUGLASS, M. S.....Assistant Chemist
S. ARTHUR JOHNSON, M. S.....Assistant Entomologist
B. O. LONGYEAR, B. S.....Assistant Horticulturist
E. B. HOUSE, M. S.....Assistant Irrigation Engineer
F. KNORR, B. S.....Assistant Agronomist
P. K. BLINN, B. S....Field Agent, Arkansas Valley, Rocky Ford
E. R. BENNETT, B. S.....Potato Investigations
MIRIAM A. PALMER.....Artist
L. C. BRAGG.....Assistant in Entomology

STATE FRUIT INVESTIGATIONS.

O. B. WHIPPLE, B. S., Grand Junction....Field Horticulturist
GEORGE P. WELDON, B. S., Delta***....Field Entomologist

President, BARTON O. AYLESWORTH, A. M., LL.D.

L. G. CARPENTER, M. S.....Director
A. M. HAWLEY.....Secretary
MARGARET MURRAY.....Clerk

*To October 19, 1908.
**From May 1, 1908.
†To be filled.
***From March 1, 1908.

LETTER OF TRANSMITTAL.

o His Exellency, Henry A. Buchtel, Governor of Colorado:

In accordance with the conditions of the act of Congress hich requires a full and detailed report of the operations of ie Experiment Station, I have the honor to present herewith ie twenty-first annual report.

The financial statement is for the fiscal year ending June 30, e other portions being reported substantially for the current ear.

The publication of the investigations is made in separate rm as bulletins, and these are freely distributed among the eople of the State.

L. G. CARPENTER,

Director.

The Agricultural Experiment Station, State Agricultural College, Fort Collins, Colorado, December, 1908.

To the State Board of Agriculture:

Gentlemen—I have the honor to submit my report for the past year as Director of the Experiment Station, with accompanying reports of the various sections.

As usual, believing that the purpose will be best served, I have had prepared two reports by each, a brief one for your special information, and a longer one for publication. The reason for this is that you need to have information to act intelligently on questions. The steps are not of public interest and need not be published. The public not being in touch with the detail, needs much fuller statements in order that they shall understand the situation. I have asked each member of the station staff to prepare a brief report and a long report with these two purposes in view, and to some extent the purpose has been reached in covering these two objects.

In this report to you the principal thing besides calling attention to some features of the work will be to call attention to the line of development and the changes that are coming in station outlook, largely as a consequence of the Adams fund, and the new relations which it introduces.

The work in the office of the Director has very much increased. While ten years ago the available funds outside of the fixed charges were very small, they have very much increased. The fixed charges, like salaries, etc., cause no particular question to to arise in the office administration. The other, or unassigned sums, introduce a great many questions, and thus, the calls from this source are ten or twenty times as much as they then were. The office work has thus correspondingly increased. The increase in the number of funds has made considerable bookkeeping necessary in the Director's office. It has been necessary to keep an account with each fund in order to foresee the needs and to prevent some of the funds running short. The mailing of the bulletins alone is a serious task. There are now over 16,000 names on the mailing list. An edition of an ordinary 32-page bulletin weighs nearly a ton. The correspondence and routine work have also very largely increased. With the increase in the number of bulletins, a larger amount of space and more system has had to be used in keeping our files. The number of engravings in our different bulletins has so increased that it has become necessary to make special provision for indexing and cataloging the cuts. The increase in the revenue also has introduced a large number of experimental projects and it has become necessary to keep closer account with each of these projects. The increasing value of the stations throughout the United States brings a large variety of correspondence on incidental

estions. The result of all of these is to throw a large addi-onal amount of work into the Director's office, and also upon l of the members of the station staff.

The office work has required three stenographers and clerks nd was so divided as to give routine work to each, all under the harge of Miss Murray. Since the first of August we have been ort one office helper. The consequence is that some of the utine work which could be postponed has been set aside, but uch of this that has been postponed would be better to be kept p. It has thrown a good deal of routine work, especially the ietation, upon Miss Murray, in addition to the many other re-onsibilities.

Through the activity of Prof. Cottrell in farmers' institutes st year, the names on our mailing list have very materially in-reased, so that now we have more than 16,000 names on the st. Ten bulletins were issued during the year, amounting to 94 pages, or a total of 2,310,000 printed pages. The bulletins nvelopes to mail a single edition cost $50. To lessen this ex-ense, as well as to lessen the labor of mailing, several bulletins re mailed together.

The matter of bulletins brings up a number of serious ques-ions. One is of ways and means, and the other is the scope of he bulletins which we should print. The pressing demand for nformation, and the attempt of the stations to meet the de-nand—because there has been no other source—has led to the ssuance of many popular bulletins. These have not been scien-ific in character and consist sometimes largely of compiled in-ormation. These have been published in the name of the sta-ions so as to have the advantage of the franking privileges, hough the expense of the compilation has been borne by other unds. This has been especially true of Cornell, and this prac-ice has led to misapprehension in other states concerning the cope of the stations where other funds have not been available. There is much doubt whether the Hatch fund should be charge-ble with the expense of such bulletins, and I presume, with the evelopment of the stations, which seems to be coming, that bjection will be made by the government to such use of the Hatch fund.

The increase in the number of names and the general demand or popular bulletins makes a very large expense. Our printing ill for the fiscal year amounted to $3,000. No way has yet been ound to distribute these publications so that many copies will ot be wasted. In many states the station funds do not have to and this expense, as the state prints the bulletins from other unds, and thus the activity of the stations, which results in more ulletins, does not have the effect of cutting down the funds avail-ble for work.

Bulletins which come as the result of scientific investigation re, with few exceptions, scientific in character, and usually can

not be expected to be popular, and will have a limited use. It has not, so far, seemed to be practicable to classify the names on the station list according to the subject that they are interested in, and, in fact, I doubt if this is advisable. The Geneva station, of New York, long ago adopted the practice of issuing two sets of bulletins—a popular edition, giving the main contents of the bulletins, but free from all technicalities, and from two to four pages in length. This means editorial supervision, and of a kind which the scientific author is not prepared to give. In that case the longer bulletin is mailed only on request. It has been found, however, that the shorter bulletins answered the purpose of most people. With the increase in our mailing list, and the probable larger number of bulletins, the expense of printing will be an increasingly serious one, and it may be necessary to adopt the Geneva plan or else to lessen the bulletins, which does not seem desirable.

In considering any new line of work and obtaining an appropriation from the State, I consider it very desirable that the sum appropriated should be large enough to cover any printing that would be required and the publication of bulletins. The propriety of using the Hatch fund to pay for printing of inquiries, which are not chargeable to the Government funds, is very doubtful, and if the propriety were not doubtful the expediency is, for, with the increase in the number of investigations which cluster about the Experiment Station, it would soon result that the Hatch fund would become nothing but a printing fund.

Last year a more systematic classification of the projects of investigation was undertaken, and blanks prepared, whereon each investigator outlined the projects which he wished to investigate, and gave definite details. The necessity for this had been increasingly evident, and the definite purpose was twofold. One, to cause each one to make a more definite plan than it had been customary; to consider in advance the definite object to be accomplished, definite methods for that purpose, and an estimate of the cost in time and in money. The second definite purpose was to cause each one to bring before himself a clear idea of the demands in time which his projects would require, and thus to cause him to reduce the number of attempted investigations. The number of questions in this State is so great that the temptation has been to undertake too many. In one case an investigator found that his projects, which he expected to complete in a year, would require nearly three years of his own time and nearly as much of an assistant.

In this, as in previous years, the Director has not attempted to interfere with plans and projects, but to guide and assist, and to cause a clear view of the element cost and time; to know in advance what to expect, and to prevent the entering upon projects which it would be impracticable to thoroughly carry out. I will not need to speak to any extent of the work in detail.

Notwithstanding these improvements in conditions, the same general fact has existed that nearly everyone has been tempted to undertake more than he could carry through. This has been partly due to an overestimate of the time available and an underestimate of the time and work required. The time required by the interference of other duties has almost always been underestimated. Other matters have this year prevented the scientific force from being able to work under the most effective conditions. Activities, as shown by the bulletins, have been maintained, but the scientific activity, which requires rather peculiar conditions, has certainly not been increased.

Some questions relating to this I will speak of more particularly in speaking of the development of the Station.

The revenue of the Station has been as follows:

From the U. S. Government, Hatch Fund	$15 000.00
From the U. S. Government, Adams Fund	8,756.22
From State Appropriations	27,500.00
From Other Sources	9,164.85
Total	$60.421.07

The conditions attached to the governmental funds—of both the Hatch and Adams—are such that they must be completely expended within the fiscal year ending June 30. In case there is any balance it is confiscated. In case there are any bills outstanding they can not be paid. This is true of each fund separately, so that it requires very careful prevision in order to bring them out exactly. The fact that the Adams fund is not even $9,000 for the last fiscal year is because the Department of Agriculture ruled that certain bills could not be paid from the Adams fund. Their previous practice had given reason to think that were proper. These were bill for books, such as Bailey's Cyclopedia of Agriculture, which were too general to be considered as required by specific scientific researches.

The State fund is the appropriation for two years. The Adams fund has special requirements, and, as previously indicated to you, has not had the effect of relieving our finances, but has required other expenditure, in order to take full advantage.

The State fund was that appropriated by the last Legislature, and includes the appropriations for special purposes. The appropriation of the Hatch fund is for

> "the purpose of paying the necessary expenses of conducting investigations and experiments, and for printing and distributing the results."

The Adams fund is

"for paying the necessary expenses of conducting original scientific research, etc."

The scientific investigations provided for by both appropriations need to be supplemented by additional funds. That is, while the experiments of an investigator leading, for example, to the production of a rust-resistant cantaloupe or the production of an improved variety of wheat, may be right and proper under the Hatch fund, the growth of that seed for distribution and its distribution is held as not being an expenditure that would be proper by the Government funds. Likewise, for example, the investigations that have led to the production of black-leg vaccine or serum for hog cholera, may be proper charges on the Government funds, yet, when it comes to the application of these to stock for commercial purposes, it passes the domain considered experimental, to the economic field. This can not be done by the Experiment Station under the Government appropriation, but might be done if other funds are provided. Now it is unnecessary to say that this part of the work is of great importance and needs to be provided for. It brings the work of the Station into actual contact with the economic needs of the farmer, and is a work which is immediately appreciated. It is for such purposes that appropriations from the State or other sources are actually needed. The State appropriations can be given under broad enough conditions, both to expand the work of the Experiment Station and to do this important work, which the Government funds can not be used for, even if they were large enough.

I attach a memorandum of the appropriations as passed by the last Legislature, and suggest that some action be taken to decide on what is desirable for the coming biennial period. The embarrassment which has been caused in the past because the State appropriations were not available until late in the fall is known to you. Our financial situation with regard to these funds is better now than it was two years ago. Having a local treasurer, it is possible to carry some of these funds, so that the balance in each, unless it be the Plant Industry and Animal Industry, will tide us over until the close of the Legislature.

In asking for additional appropriations, I would suggest that the appropriation in each line should be sufficient to pay all expenses, both direct and indirect, caused by the additional work. Thus the Fruit Investigation will illustrate. In this case the appropriation pays not only the traveling, office and other expenses, but also the salaries of the two men who are employed. It is also desirable to pay the expense of printing that is called for by it. The only expense thrown upon the Station and College is, therefore, the time required by the Horticulturist and the Entomologist, and of office work and some minor printing, etc., in all a very small amount.

The arrangement has been different with, for instance, the Plant Industry, where no salaries have been charged to this fund, except the wages of the laborers employed from time to time. In this case, therefore, the aid from the State causes the College to spend a large additional amount of money, and the same thing has been true of some of the other appropriations. I would therefore recommend that the amount asked for for Plant Industry, Animal Industry, etc., should be large enough to pay a proportional amount of the salaries of the men called for. Thus, for instance, the potato investigations for the past two years have been maintained by the College, and a small portion from the Experiment Station. This ought to be provided for by the legislature.

The memorandum is made as a suggestion. An explanation of the memorandum is attached to it.

It is proper to undertake some additional lines of work. Considerable call has been made at times for so-called experimental farms in different parts of the State. There is some good in these if too much is not expected. The community is apt to consider them as model farms, which is different even from demonstration farms or experimental farms. If a demonstration farm, the principal purpose would be teaching—that is, to show the application of principles already well known. A great difficulty is to get capable men. If a sub-station is established the community is apt to consider it as a model farm, and the superintendent is thus judged by the community by the way in which he maintains the place. Each one also expects a specialist who knows more about each crop than the most skilled man in the community. It is impossible for one man to meet all these standards, and especially for the sum of $800 to $1,200 per year, which is usually the amount available. There is, however, a field for demonstration farms or for test farms, in different parts of the State. It is objectionable and misleading to call them experimental farms. They are, however, expensive, and the same amount of money can do much more good in some other ways. The number of people who visit one of these places is small, so that as an educational influence its field is very limited. Calls have been made for such on the Plains. It is found that only a few visit these places, and the advantage, judging from past experience, would not be any better over many selected farms. Eastern Colorado is so big that the same amount of money could reach many more people by collection and distribution of information over that extensive area. Desires have been expressed for some such station in northwestern Colorado.

If it be thought best to undertake anything of this kind the assured income should be not less than $3,000 for each one per year. It would probably be better and more economical to arrange with some farmer in these localities and possibly make a

contract with him so that he will carry out instructions and raise crops as directed under approved methods, and in that case the cost might be brought down. The difficulty then would be for our present force to find time to give the necessary attention. One man might take up this special line of work and enough test farms of this kind be taken in different parts of the State to give him a reasonable amount of employment. In that case the assured income ought to be not less than $1,000 per annum for each. Such a method might avoid the necessity of buying farm machinery, teams and other equipment, which runs very quickly into money, and means a continuing expense to maintain.

The problem of the Plains has been brought up at various times. Some desire has been expressed for a substation there. The present condition calls for distribution of information rather than for additional substations. Their need is immediate. If there were the funds available a series of special institutes or meetings might be of very great value on the Plains, so as to meet the problems to some extent that are confronting the people there. The indications are that many have already moved out and that many more will move out before spring, or be pushed by dire necessity.

HORSE BREEDING WORK.

No report is available concerning the conditions of this investigation. The peculiar form of agreement with the U. S. Department of Agriculture has left the duties of the Director in somewhat ambiguous state, and the Director's office is possessed of little information. There have therefore been no reports in times past concerning the progress of the work, except a very short statement in the annual report. I learned sometime since that the Committee on Purchasing had recommended that a number of these colts be sold, and I obtained a copy of the report by applying to the Department of Agriculture at Washington. The opinion of all concerned is that the quicker these are sold the better, as it would relieve the investigation of the care and maintenance of these animals. The money derived from the sale of these colts would be returned to the Station or College as a portion of the cost. As the matter is somewhat in doubt, I bring it to you for action to order the sale of these animals, or to authorize the Director to take action. The sale might be either by public auction or a private sale. In the latter case a minimum price might be fixed. A third method has been suggested and that is to send these animals to Chicago or Omaha, so that their identity might be lost, and thus they could not be represented as being from the Government breeding station here. When this contract with the Government comes for revision I would be inclined to suggest some minor changes. As an administrative matter there should not be ambiguity concerning those relations to the Station and to the College. The

present ambiguous condition has rendered it possible to interpret so that knowledge of the development or progress has not been on record either in the office of the Secretary, President or Director.

FUTURE DEVELOPMENT OF THE STATION.

A large part of the recent meeting of the College and Experiment Stations was taken up with the consideration of the question of research, and Station organization and policy. These questions have become of greater importance with the changes brought about by the Adams fund. Nearly all of the Stations are feeling the effects. A noticeable fundamental effect is the changed outlook upon scientific work. The Hatch appropriation was considered as secondary to college work. The tendency was to take up chemical work or entomological work, or any other line, because the College had a chemist or an entomologist. The fund was looked on somewhat as a means to obtain superior men for College work and to help pay them. The fund was therefore looked upon as an addition to the College.

The Adams act and its requirements change this. It now makes the scientific project the unit and bigger than the man. The chemist, for instance, is now employed because chemical investigations are required. The changes thus introduced in the outlook of the Station and its relation to the College will be fundamental, and will cause the Experiment Station of the United States to occupy a very different position in the course of a few years. It is not at present a question whether we look on these changes as desirable. They seem to be inevitable if the law remains as it is, and there seems to be no probability that any change will be made. With the increased revenue of the Stations, and this change in outlook, and the additional supervisory power given to the Department of Agriculture, the Stations will become more and more institutes of research in the narrow sense. The requirements of the Adams bill will react upon the Hatch fund, and will undoubtedly alter the view of many scientific investigators.* There is no doubt that we have been undertaking too much and that much more has been attempted by each man than he could do. The work of teaching has generally been considered primary, and such investigational work as has been done has been done at odd times or in vacations and as a secondary matter. If there was conflict the teaching kept the first place, and this meant that the Station work suffered.

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*In the Experiment Station Record for December, issued since this report was read, the U. S. Department of Agriculture says that a stricter interpretation will be given the Hatch Act, and "no longer to permit expenditures from that fund for Farmers' Institute work, extension teaching or the preparation of compilations."

It is to be expected that the Government will require the Institutions to provide the best conditions for scientific work, and that the men who are on the Adams fund must consider this work as primary. If there be conflicts between the scientific work and teaching, for instance, then the Government is in position to insist that the scientific work shall not suffer. These changed conditions, therefore, are affecting other Stations as well as our own, and makes this a period of transition from the former loose basis to the future one where scientific investigations will be primary. The Stations are working this out, but as yet have not all reached the same conclusions as to method.

The general recommendation for carrying out the policies is toward reducing the number of lines of work; to select a few important subjects and then to let the work of the various men cluster about these projects. This prevents some of the distribution of effort on unimportant work, which may seem to be popular, but is unimportant in the long run. The tendency is to reduce the amount of teaching. Nearly every investigator is also a good teacher, and, under pressure of demands as well as his own impulse, he is apt to teach more than is desirable. Teaching even an hour a day breaks up the continuity of the investigator's work of the highest class. Extension work and work of Farmers' Institutes, and likewise work which is called popular, is apt to be in conflict. There is often pressure for Stations to do inspection work, as the inspection of fertilizers, injurious insects, animal diseases, etc. All of these are proper in their own line, but also are considered objectionable. Each of these questions bring up serious matters for consideration. Some Colleges are taking the position that the Experiment Station should be entirely separate from the College, and thus have, for example, two chemists and a duplication of other officers, so that the teacher does not investigate and the investigator does not teach. It is in this way that some of the Institutions interpret the provision of the law that the Station shall be a department of the College. In others, like our own, the Station work is a part of several departments, and the various departments are the unit. There is carried on in each department both teaching, investigation and extension work. While the majority of institutions are separating the Stations, I am inclined to think that our arrangement is better for our conditions, at least for the present, both for the College and for the Station.

A Committee of six of the most prominent Directors in the United States formed a committee on Station organization and policy. Their report, or even their conclusions, is too long to repeat. Concerning inspection work the committee recommend that this be kept entirely separate from scientific work, and that if it be undertaken that it be from separate

unds. They recommend that the investigator should be free rom the routine of teaching, and further recommend in their onclusions that the ideal policy would be for the investigator o be free from such responsibilities, and, as a step, that the eaching be limited to a maximum of three hours per week for ne term in each year, and that this be along the lines of his pecialty.

This report and also the report by the Committee on Scien- ific Research, of which David Starr Jordan, of California, was hairman, will be read in full to the members of the Station taff.

The reprint of this Committee is too long for quotation, ut their conclusions which were accepted as the conclusions f the association deserve weight as the conviction of men who re giving much attention to these problems, and is worth quota- ion as bearing on the general question of Station policy reached n the study of relation between research and administration and lso upon the matters affecting the continuity of Station work.

RELATION BETWEEN RESEARCH AND ADMINISTRATION.

"(1) The station exists primarily for research in the in- erest of the public service. If, however, this research is to be nade effective there must be administration as well as investi- ation, and both reason and the dictates of justice demand that he scientific worker and the administrative officer be mutually ympathetic and helpful each to the other.

(2) The unit of work is the individual, and nothing should ome between him and his research. That organization is best, herefore, which most accurately defines the field of each station vorker, protects him in his investigations within that field, in- ures funds and equipment for the pursuit of research, and in he end secures results that are useful to the public that pays he bills.

(3) Administration as such does no work. At best its unction is correlation as between internal interests on the one and and as between these and the external or public interests pon the other. In theory all administration means delay and ome necessary interference with individual initiative. This is nfortunate, but inevitable, though its compensation lies in the ncreased certainty that interests will not clash within and that he public needs may be well served, an end that requires the ounsel of many minds. In interests of work, therefore, the less dministration the better, if only the proper ends are attained, ut workers must recognize the necessity of something like or- anization, which means administration.

(4) The chief functions of administration in respect to a iece of investigation may be enumerated as follows:

(a) To help to determine in advance whether the proposed esearch is profitable and altogether advisable from the stand-

point of the public, whose representative for the time being the administrative officer must be.

(b) To assist in determining what lines of experimentation are calculated to throw profitable light upon the problem.

(c) To help to determine whether the work is best carried on by one individual representing a single line of inquiry, or by two or more working in conjunction, and if the latter, to secure in advance a complete understanding as to mutual duties, rights, and responsibilities. Upon all these points the judgment and the point of view of the administrative officer is not only likely to be broader, but certain to be freer from personal bias than is that of the professional investigator.

(d) The experiment once decided upon, however, and the funds provided, administration is over until results are due, when it begins again and does not cease till reports are published and circulated. The less administration during the progress of the work the better for all interests, and if the need of it becomes clear it is the best of evidence that administration was remiss at the outset. Your committee cannot too strongly point out the necessity of the entire freedom as to methods of investigation on the part of the staff worker who has been employed because of his expert knowledge of the matter and methods of work in a highly specialized field.

(5) To secure these two ideals of administration efficiency and sympathetic helpfulness without interference requires for administrative officers men not only of good business methods and large outlook, but also with the highest obtainable training along some important line of science as related to agriculture.

(6) If the organization be large the department plan will of necessity be employed, and administration will be exercised largely through the head of the department. Besides his administrative function the department head will have, or should have, a special line of his own, and as he himself values a free field with no interference, so should he accord the same privilege to every member of his department; that is, he should take no advantage of his administrative superiority to invade the field of work of another. Such an individual, exercising the double function of administration and work, must needs exercise great care as to when he operates under the one capacity and when under the other.

(7) This principle is best fixed by an illustration in a large department, containing men of all degrees of proficiency from the novice with the title of assistant up to the skilled investigator with a title equivalent to that of full professor. Over the one the department head must needs exercise much supervision, even to the point of daily direction, but over the other he only injures the work by presuming to direct. The point is that when an officer, holding the double function of worker and of administrator, directs the work of another he does it not

as an administrative officer, but as a department superior directing his assistant.

(8) The principle applied to the director means that as director he is not responsible for and should not attempt to control, much less direct, the details of procedure in a scientific investigation. Again, the principle gets its best illustration in a case where the staff worker is not only entirely capable of conducting the details of research, but is greatly the superior of the director himself as to skill in scientific method. Such cases are not rare; indeed, if our stations were equipped, as they should be, with large numbers of strong and independent men, this would be the common occurrence, in which case the director could not presume to expert knowledge in all its various fields of research and experimentation.

(9) If the station be small, the director occupies much the position of a department head, and if the workers are young and inexperienced, he will of necessity keep close to the work. Nevertheless, it is even then better for the director to carefully refrain from exercising administrative pressure or authority in respect to investigations and couch his influence in terms of advice and sympathetic assistance. This is the only way to develop strong investigators from young men, as it is the only way to deal with investigators if they are strong already, and until we can fix the principle that in station work the labors of the scientist shall be free from administrative interference, we shall not be able to attract into agriculture the ablest men or to hold them when we get them. Your committee is credibly informed that instances are not wanting in which good men have left the work because the director felt free to criticise, even to direct, in scientific details about which he knew practically nothing.

(10) As a means of establishing and maintaining a strong organization without a galling and depressing effect of too much administration, three things are helpful: First, that every administrative officer fully respect the position of every other, whether superior or inferior, and never go around him for any purpose whatever; second, that a regular succession of administration be established, so that, in the absence of any officer, another at once steps into his place, exercising not quasi, but actual, authority so long as he occupies the position, all of his acts to be as fully respected as are those of the regular appointee; and, third, that there be frequent and full conferences between administrative officers and all others where work and administrative duties come together. In all these ways a full understanding will be assured, and nearly everybody, at some time or other, will get some experience with administration.

(11) The committee does not favor a weak organization, but, on the other hand, one that is strong enough to recognize the interests of the whole Station as above those of any other department or separate interest, and strong enough to enable the entire

influence of the whole body to be exerted in any desired direction on short notice. If this is to be accomplished, everybody must feel free, and not the object of arbitrary rulings. The test of the esprit de corps of such an organization is whether or not it will support, as it should, a position that needs to be taken by the highest administrative officers."

CONTINUITY OF STATION WORK.

"The following are claimed to be some of the frequent causes of lack of continuity of effort:

(1) Too frequent changes in the working force.

(2) The dropping of work before its completion in the effort to meet some actual or supposed popular clamor for new lines of investigation.

(3) Insufficient and too infrequent advances in the salaries particularly of the older men, and their consequent withdrawal to accept more lucrative positions elsewhere.

(4) Lack of equipment and facilities for investigation; for example, the lack of fields for experimental work at the outset involving shifting from one place to another; also delay in undertaking some of the most vital problems and the necessity of taking up less important lines of work as temporary expedients.

(5) Government by a Station council rather than by director, resulting in a change of policy with changes in the personnel of the council.

(6) The assumption, in some cases, of the function of the director by the president. For example, relief of the director from all financial responsibility, a policy which deserves strenuous discouragement.

(7) The amount of teaching and extension work required of Station officers.

(8) The forcing upon the stations of men in the college who are not adapted to do research work.

(9) The occasional appointment of incompetent men directors or heads of departments, which necessarily involves poorly planned experimental projects and necessitates changes a later date; also the appointment of politicians and of others for political or personal considerations.

(10) Occasional sudden changes of entire boards of management in certain states and territories, resulting frequently abrupt and most serious changes in policy.

(11) Undertaking too many lines of work and attempting to cover too wide a field."

Under the terms of the Adams act the projects undertaken are subject to the approval of the Government, and, after one undertaken, it is then almost necessary for the Station to carry them through. We are limited in the expenditure of money

the approved projects and to the necessary equipment and expenses in connection therewith. This helps to force a continuity of effort and carefulness in planning. Thus, last winter, when it became evident that some lines of work which had been planned in plant diseases could not be carried out by Professor Paddock, this pressure made it necessary to consider how the work could be carried on, and led eventually to the necessity of obtaining a special bacteriologist, Mr. W. G. Sackett, who was employed entirely at the expense of the Adams fund, and who gives his entire time to Adams fund investigations. There has been considerable desire for him to teach, but, manifestly, this could not be done until arrangement was made for paying at least a corresponding part of his salary from other than Station funds. The arrangement with Mr. Sackett was that he was to come at $1,600 per year, and that, if satisfactory, he should be raised to $1,800 by the end of the year; and, as this has been the case, I would recommend that, starting from the first of January, his salary be $1,800 from the Adams fund. If it be desirable that he teach during the winter term, then that $1,500 be paid from the Adams fund and $300 from the College funds.

Some of the special problems which are brought about by our Station organization are those relating to the staff and the calls of the College. There are some who are paid only a small amount from the Station, and some who are paid none at all, and some who are paid a large amount from the Station. The tendency has been to increase the amount paid by the Station to those who are devoting a large part of their time to scientific work, and especially to Adams fund work. The general experience seems to be that it is better to obtain fewer men and to pay a larger part of their salaries from this fund. The pressure toward reducing the amount of teaching necessarily means that some others in the same department must spend a larger amount of time in teaching. This creates some dissatisfaction, as there is a triple standard to which the different members are held. Some are inclined to think that the whole duty of the professor is to teach. People who attend the farmers' institutes are disappointed unless they hear the heads of the departments. The larger world will judge a man by his Experiment Station investigations. It is impossible for the heads of departments to meet all of these demands. The tendency has been for one to still be the responsible head and to direct the general work, and to be relieved of some of the routine work, so as to be able to give such time to the problems on which he is working. The general conditions may force a reduction in the number of the Experiment Station staff, but this is not, perhaps, to be desired. There are, however, a number who have been paid a small sum—for instance, $100 per year—partly as a means of saving embarrassment in the departments. It is a question whether, from the Station standpoint, this course is advantageous. As it has been in the past, the Station men have

received less pay than those on the College, where the requirements are greater, and, as a whole, they have been held to more strenuous requirements; so, in departments where some men are on the Station roll, some on the College, the fact that the College men are relatively free concerning their hours, and may be entirely free during the summer vacation, has sometimes caused complaint among the Station men. It is undoubtedly proper for the College to aid the Station, either by direct appropriation or by paying men who may be assigned for more or less of their time to Station work. The law, however, does not permit the Station to pay men for the purpose of aiding the College. It might be considered that the expenditure by the College has been more than offset by the fact that the Station appropriation enables the College to do work that its own funds have not been sufficient to do. I doubt if the practice of paying a small sum to meet this embarrassment is good policy. The embarrassments that have arisen in times past have been brought to your attention before. They involve some questions of College policy, and may lead to a question of special understanding with each person. So far as the question involves the Station, the embarrassment may be relieved if the Board should see fit to rule that those who are in departments forming sections of the Experiment Station should be under the direction of their chief during the summer as well as during the rest of the year. There would still remain some dissatisfaction as between such departments and those where work is not carried on at all during the summer.

The adjustment of teaching so as to be of best value to the department and Station is another matter that will gradually work its way out.

Is it proper for the Station to print popular bulletins of information, especially from the Hatch fund? There is undoubtedly a call for these. How is that to be met and to what extent should Station people do such work? There is undoubtedly a feeling among Station men that the so-called popular work is not the proper work for the Station investigator, and it is evidently the belief that fundamental work is of more importance. There is also a lingering doubt in the minds of Station workers of the expediency of trusting themselves too entirely to scientific work because of the feeling that there is not at present a proper recognition by the public and by the Boards of Control of what constitutes scientific work and therefore proper moral support.

Foreseeing these questions I have given a good deal of thought during the past few years to the development that was eventually coming. In many cases I have not reached conclusions that I am satisfied are best. The change, however, is taking place as fast as conditions require it, and all the Stations in the United States are working at the solution of the same general questions. As I called to your attention some

years ago, the fact of the passage of the Adams act would not be to relieve the College finances as was hoped, but increased our responsibilities more than it increased our revenue.

The tendency undoubtedly will be to reduce the lines of work, but may require as many, if not more, people. Thus, for instance, in the past we have done something concerning alkali from the chemical side, because we had a chemist on the Station. Now the tendency would be to take up the alkali question, for instance, and then the different members of the Station would work in unison upon that problem. The chemist from the chemical side taking up the chemical features; the bacteriologist the side of bacteria of alkaline soils; the irrigation engineer from the standpoint of drainage and of prevention, and perhaps the botanist from the standpoint of determining what vegetation may be grown on alkaline soils, etc.

Thus with this development the different Stations would take up different general questions. Some Stations become known for their work in feeding, and the results of such investigations would be valuable everywhere; other investigations in fruit questions; and other investigations in poultry culture.

Our conditions in this State, the development of our State, has made irrigation the foundation question, and our natural development is on the lines related to it. This does not mean that such is the only question, but on it we stand under unique conditions.

RECOMMENDATIONS.

The general statements above show in some degree the character of the questions that have had to be considered in a broader way in the year past, and some of the tendencies which I think are affecting us, and will cause a readjustment of Station work. We will have to settle some of these in the light our own conditions. Many will settle themselves as fast as can be expected.

There are comparatively few matters that I have to bring up for direct recommendation. One is concerning the salary of Mr. Sackett, that provision be made to raise it from $1,600 to $1,800 per year, beginning with the first of January.

I would recommend that a determination be made of what should be asked from the Legislature. This list attached is simply a memorandum as a basis for consideration.

In the above report I have called attention to conditions, but have not attempted to make specific recommendations, for most of these I think are in condition to solve themselves, with some patience and some guidance.

As a whole the problems in this State are interesting and important in character, and the work that the Station has done has met recognition both here and elsewhere. In the long run

the Station will be judged by the work of a thoroughly scientific character, which may or may not be popular at the time. It is, however, this kind of work that is the fundamental work for the Station's usefulness. The so-called popular work must be founded on the scientific work, and the scientific work must, therefore, go ahead of the popular work.

The distribution of the results through extension or demonstration work, is a duty that is owed to the people, but, as I have attempted to show, is only to a limited extent chargeable to the Government funds, therefore, must be supplemented by State appropriations or other sources of revenue.

Prospects are bright, and while the Station and its work is in the transition period, yet it will be worked out under conditions as they develop with the purpose of being of the greatest value to the agricultural interests of the State.

The reports of the separate sections are collected and give many details of work not here referred to. Request was made early in October for reports, but none were presented by those whose responsibility ceased in that month.

Respectfully submitted,

L. G. CARPENTER,
Director.

NEEDS.

1. Fruit Investigation, past appropriation $8,000, only sufficient for the payment of the men at Delta and Grand Junction. The scope of the bill is broader and something ought to be done in other parts of the State. The amount ought to be at least $10,000.

2. Plant Industry, for the last two years $6,000. This does not pay any salaries, and includes $2,000 for building. This amount is not large enough, and ought to be either $8,000 or $10,000.

3. Animal Industry, $6,000 for the past two years. It ought to be as much for the coming two years, or probably more. The previous sum was available both for investigations concerning stock, also concerning feeds and feeding. The feeding problem is important enough to be considered separately, and I would recommend that a separate sum be asked for experiments in feeds and feeding.

4. The potato investigation did not have an appropriation the last biennial period. We had $1,000 for the biennium before. The Experiment Station has paid $600 of the salary of Mr. Bennett, and the College has paid the rest of the sum. Part of the expenses have been borne by the Station. This work is largely of the nature of teaching and extension work. This work should require for the

two years $6,000. This would only allow $1,200 besides salary, and would be sufficient to publish one bulletin, and pay the field expenses.

5. Animal Diseases. $500 received for the last biennial period. The development of the Veterinary department has largely taken the time of Dr. Glover. If an appropriation could be had there might be a start made in the distribution of serum for hog cholera, and special investigation of other diseases. This serum distribution is not a proper charge on the Experiment Station funds.

6. Farm Mechanics, $2,000 received during the past biennial period, of which one-half was used for building. There is still a balance of $600.

7. Horse Investigation, $5,000 was received. There are beginning to be some receipts, but nowhere near enough to maintain this breeding work. There ought to be as much more available during the next two years. There is a balance of $1,500. No salaries have been charged to this fund. There was $1,000 used for land; a large part of the rest has been used for equipment in the way of sheds, feeding racks, fences, etc.

8. Irrigation Investigations. Nothing was asked for in the previous period. This can be one of the most fruitful lines, and a systematic investigation of the water resources and application of water would be of very great benefit, and I would therefore recommend that from $6,000 to $10,000 be asked for for this purpose.

9. Lands. This previous bill provided for $7,500 for lands. The College is in debt for a large amount and it would be desirable to obtain as much as possible.

10. Building and equipment of the Irrigation Building. To complete and equip the building would require at least $70,000.

FINANCIAL REPORT OF THE COLORADO AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING JUNE 30, 1908.

RECEIPTS.

DR.

From the Treasurer of the United States, as per appropriations for the fiscal year ended June 30, 1908, under acts of Congress, approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)	Hatch Fund.	Adams Fund.	State Fund.	Special Fund.	Totals.
	$15,000.00	.....	.....	.....	.....
	.....	$ 8,756.22	.....	.....	.....
Appropriation by State Legislature	.....	.....	$27,500.00	.....	.....
Balance on hand July 1, 1907	.....	.....	.....	$ 842.33	.....
*Transfer	.....	.....	.....	3,716.18	.....
Other sources than the United States	.....	.....	.....	9,164.85	.....
Total receipts					$64,979.58

DISBURSEMENTS.

By Salaries	$ 9,273.16	$ 5,749.78	$ 1,647.50	$ 1,045.00	$17,715.44
Labor	620.80	5.45	1,548.86	867.43	3,042.54
Publications	3,042.55	.....	.....	.....	3,042.55
Postage and Stationery	337.94	9.32	212.45	62.55	622.26
Freight and Express	112.20	107.58	192.78	214.19	626.75
Heat, Light, Water and Power	.....	120.64	14.85	16.00	151.49
Chemical Supplies	137.80	175.35	1.00	14.90	329.05
Seeds, Plants and Sundry Supplies	48.58	103.17	420.26	57.53	729.54

Fertilizers	.....	.....	.....	.....	.....
Feeding Stuffs	.....	.....	1,084.89	434.77	1,519.66
Library	165.86	25.53	.....	107 23	298.62
Tools, Implements and Machinery	2.75	3.00	56.10	557.30	619.15
Furniture and Fixtures	565.60	555.35	17.80	111.75	1,250.50
Scientific Apparatus	37.97	942.25	98.23	51.36	1,129.81
Live Stock	.....	15.80	1,652.34	1,642.39	3,310.53
Traveling Expenses	489.79	493.00	251.90	446.70	1,681.39
Contingent Expenses	15.00	.....	343.78	184.25	543.03
Buildings and Land	50.00	450.00	1,943.85	602.35	3,046.20
Total Expenditure	$15,600.00	$ 8,756.22	$ 9,486.59	$ 6,415.70	$39,658.51
†Transfer			4,986.02		4,986.02
			$14,472.61		$44,644.53
Balance			13,027.39	7,307.66	20,335.05
			$27,500.00	$13,723.36	$64,979.58

*Special appropriation by State Legislature for the two years from December 1, 1906, to November 30, 1908, inclusive.

†To reimburse for funds advanced before funds provided for by Legislative appropriation became available.

Advanced from College Funds	$1,269.84
Advanced from Special Funds	3,716.18
Transferred from Appropriation	$4,986.02

BULLETINS ISSUED DURING CALENDAR YEAR OF 1908.

No. 126. Cantaloupe Breeding, by P. K. Blinn.

No. 127. Climate of Colorado, Temperature 21 Years' Record at Fort Collins, by L. G. Carpenter and R. E. Trimble.

No. 128. Alfalfa Studies, Progress Report, by P. K. Blinn.

No. 129. Extraction of Beeswax, by F. C. Alford.

No. 130. The Evergreen Trees of Colorado, by B. O. Longyear.

No. 131. Arsenical Poisoning of Fruit Trees, by Wm. P. Headden.

No. 132. Destruction of Concrete by Alkali, by Wm. P. Headden.

No. 133. A Few Orchard Plant Lice, by C. P. Gillette and E. P. Taylor.

No. 134. Orchard Plant Lice and Their Remedies, by C. P. Gillette and E. P. Taylor.

No. 135. Australian Salt Bush and Notes on Russian Thistle, by Wm. P. Headden.

BULLETINS ISSUED DURING YEAR 1908.

No.	Pages.	Edition.	Total No. of Pages.
126	10	15,000	150,000
127	12	15,000	180,000
128	8	15,000	120,000
129	16	15,000	240,000
130	32	15,000	480,000
131	28	15,000	420,000
132	8	10,000	80,000
133	48	5,000	240,000
134	16	15,000	240,000
135	16	10,000	160,000

EXCHANGES.

BOOKS, PAMPHLETS, SCIENTIFIC PROCEEDINGS, ETC., 1908.

AUSTRALIA:

Journal of Department of Agriculture, Victoria.

Bulletins 31-40, inclusive.

AUSTRIA:

Sugar Beet Seed Breeding Station.

CANADA:

Appendix to Report of Minister of Agriculture; Experimental Farms.

Bulletins 57, 58, 59, 60.

Experimental Farm, Lethbridge, Alberta; Alfalfa Growing.

Le Naturaliste Canadien.

Annual Report of Department of Agriculture, Province of Saskatchewan.

Report of Cattle, Horse and Sheep Breeders' Association.

Report of Department of Agriculture and Immigration.

CUBA:

Circular 27, Black Leg and Vaccination.

Circular 29, Wounds of Animals and Their Treatment.

Bulletins 9, 10, 11.

ENGLAND:

Bulletins 177, 178, 179, 183, 187, 188, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204.

Circular 18.

Production of New Types of Forage Plants, Clovers and Grasses.

Report on Injurious Insects in Midland Counties.

Journal of Royal Horticultural Society.

FRANCE:

Journal d'Agriculture Protique, Paris; September, October, November, December.

FINLAND:

Berattelse ofver Skadeinsekters upptradande i Finland.

GERMANY:

Station fur Pfanzonschutz ozu Hamburg Sonderdruck 5.

Station fur Pfanzonschutz ozu Hamburg Sonderdruck 3.

Station fur Pfanzonschutz ozu Hamburg Sonderdruck 4.

Station fur Pfanzonschutz ozu Hamburg Sonderdruck 9.

Notizblatt des Konigi botenischew Gartens und Museums zu Berlin—Gaglenn, Index and Appendix 1 to 9.

Bulletins 1 to 42.

EXCHANGES—Continued.

INDIA:

Memoirs of the Department of Agriculture in India.

Annual Report of Agricultural Chemist.

The Agricultural Journal of India.

ITALY:

R Stazione Di Patologia Vegetale. Studi sul Marciune delle radici nelle viti fillosserate.

Bolletino della Arboricoltura italiana.

JAMAICA:

Department of Agriculture.

JAPAN:

Bulletin of the Imperial Central Agricultural Experimental Station, Japan.

The Insect World, Gifu, Japan.

MEXICO:

El Agricultor Mexicano La.

La Reproduction Del Ganado Vacuno, Chihuahua.

Algunas Plantas Forrajeras.

Veinte Plagas De La Agricultura.

Los Silos Economicos.

La Canagria.

Cantidad De Agua Necessaria Para Riegoo.

NEW SOUTH WALES:

The Agricultural Gazette, Sydney.

Report of Second Session, Legislative Assembly; Botanic Gardens and Government Domains.

Improvement of Cereals by Crossing and Selection.

NEW ZEALAND:

Extracts from Fourteenth Annual Report; Reports of 1906, Experiment Station.

Bulletins 1, 2, 5, 10, 12, 16, 17, 18, 19.

Leaflet 10.

Agriculture in New Zealand.

Fifteenth Annual Report of Department of Agriculture.

Poultry Report.

Report of Division of Biology, Horticulture.

New Zealand Official Year Book.

Agriculture in New Zealand.

Immigrants' Guide and Settlers' Hand Book.

EXCHANGES—Continued.

SOUTH AMERICA:

Boletin da Agricultura. Sao Paulo.

Boletin del Ministerio de Fomento, Lima, Peru.

Boletin del Ministerio de Agricultura, Biunos Aired.

Boletin da Agricultura.

Boletin del Ministerio de Fomento, Lima, Peru,

A Lavoura Boletinda Sociedade de Agricultura; December, January.

Boletin da Agricultura.

Boletin del Ministerio de Fomento, Lima, Peru.

Boletin da Agricultura.

A Lavoura, Boletin da Sociedade Nacional de Agricultura.

Boletin del Ministerio de Fomento.

O Criador Paulista.

Boletin de Agricultura.

Boletin da Instituto Agronomico.

Boletin y Registro Official de la Dirrecion Obras Publicas e Irrigacion

Anales de Muses Nacional.

Ballettino Arboricottura Xlatiana.

Cronica Agucila.

SOUTH AUSTRALIA:

Journal of Department of Agriculture of South Australia.

The Codling Moth; Results of Experiments with Arsenate of Soda.

Butter and Cheese Factories, Milk Stations and Condensories.

Bureau of Horticultural Inspection, New York.

Transactions of Massachusetts Horticulture Society.

Journal of Department of Agriculture of South Australia. (Adelaide.)

Bulletin 27; Roseworthy Agricultural College; Second Report on the Permanent Experimental Field.

Bulletin 29; The South Australian Wheat Yield Season.

Report of Department of Agriculture and Intelligence.

Boletin del Ministerio de Fomento.

Notes on Agriculture in South Australia.

SOUTH AFRICA:

The Transvaal Agricultural Journal.

SPAIN:

The Great Millet or Sorghum in Madras; Bulletin 55.

SWEDEN:

Tidskrift No. 405.

No. 12, Uppsatser Praktisk Entomologi, Stockholm.

No. 13, Uppsatser Praktisk Entomologi, Stockholm.

EXCHANGES—Continued.

No. 14, Uppsatser Praktisk Entomologi, Stockholm.

No. 15, Uppsatser Praktisk Entomologi, Stockholm.

No. 16, Uppsatser Praktisk Entomologi, Stockholm.

No. 17, Uppsatser Praktisk Entomologi, Stockholm.

Handlinger Och Tidskrift, Stockholm.

Journal of Agriculture, Volume 4.

Chemistry as a Factor in Agriculture. (Melbourne.)

Journal of Agriculture, Volume 3.

Closer Settlements Regulations Governing the Acquisition and Disposal of Lands.

The Victoria Settlers' Guide and Hand Book of the Land Laws.

Orchard Pests and Their Treatment.

The Journal of Department of Agriculture, Volume 5.

UNITED STATES:

Annual Report (30th), Providence Public Library.

Annual Report (31st), State Board of Health, New Jersey.

Annual Report of State Board of Horticulture of Missouri.

Annual Report of Michigan State Board of Agriculture.

Bulletin, Georgia Department of Agriculture; Commercial Fertilizers.

Bulletin, Department of Agriculture of Pennsylvania.

Bulletin, Marathon School of Agriculture, Etc., Wausau, Wisconsin.

Bulletin, North Carolina Department of Agriculture; Report of Farmers' Institute.

Bulletin, North Carolina Department of Agriculture; Stock Feeds.

Bulletin No. 14, New York Botanical Gardens, No. 19.

Bulletin, State Horticultural Society; Plants of Iowa. (Des Moines.)

Bulletin, State Board of Health of Maine.

Bulletin, Wisconsin Natural History Society.

Bulletin, North Carolina Department of Agriculture.

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Crop Reporter.

Clarkson Bulletin.

Colorado Scientific Society; Esperanto and its Availability for Scientific Writings.

Department of Agriculture of Alabama; Report on Fertilizing and Soil Surveys.

Department of Agriculture of Maine; The Orchards of Maine.

Florida Quarterly Bulletin, Tallahassee, Florida.

Georgia State Board of Entomology; Circular No. 6.

Georgia State Board of Entomology; Bulletin 25.

EXCHANGES—Continued.

Georgia State Board of Entomology; Peach Leaf and Yellows.

Georgia State Board of Entomology; Circular No. 8.

Journal of New York Entomological Society, New York City.

Journal of New York Botanical Garden.

Kentucky Crop Report.

Laboratory Bulletin 13, Oberlin, Ohio; Development of Nestling, etc.

Long Island Agronomist.

Maine Department of Agriculture.

North Carolina Department of Agriculture; Feeding Stuff Laws.

North Carolina Department of Agriculture.

Pure Products.

Proceedings of the Colorado Scientific Society.

Plants of Iowa; Bulletin of State Horticultural Society.

Production of Lumber, Lath and Shingles.

Report of Secretary of Canadian Seed Growers' Association, Ottawa, Canada.

Report of Kansas State Board of Agriculture.

Report of Kansas State Board of Agriculture.

Report (18th), Missouri Botanical Gardens.

Report of the Kansas State Board of Agriculture.

Report of the West Virginia State Board of Agriculture.

Report and Catalog of Louisiana State Museum.

Report (4th), Biennial, Montana State Board of Horticulture.

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Smithsonian Institute; United States National Herbarium Studies of American Tropical Ferns.

Training School.

Transactions of Iowa Horticultural Society.

Transactions of Massachusetts Horticultural Society.

Therapeutic Notes.

Tuberculosis in France; Daily Consular and Trade Reports.

University of Illinois Bulletin; A Study of Roof Trusses.

University of Illinois Engineering Experiment Station; Comparative Tests of Carbon, Metallized Carbon and Tantaleum Filament Lamps.

University of Illinois Engineering Experiment Station Bulletins.

Wilson Bulletins.

Wisconsin State Horticultural Society. (Spraying.)

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EXCHANGES—Continued.

SCIENTIFIC PERIODICALS:

Insect World, Gifu, Japan.

Kungle, Landtbrusk-Akademiens Handlinger Och Tidskrift, Stockholm, Sweden.

Le Naturaliste Capadieu, Chicoutimi, Quebec, Canada.

AGRICULTURAL JOURNALS:

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American Farm World, Augusta, Me.

Agricultural Southwest, Wichita, Kan.

American Sugar Industry and Beet Sugar Gazette, Chicago.

Agricultural Advertising, Chicago.

Agricultural Epitomist, Spencer, Ind.

American Hay, Flour and Feed Journal, New York.

American Fertilizer, Philadelphia.

American Farm Review.

Colorado Fruit Grower, Paonia.

Colman's Rural World, St. Louis.

Elgin Dairy Report, Elgin, Ill.

Farm Scientist, Chicago.

Farmers' Guide, Huntington, Ind.

Farmer and Breeder, Sioux City, Iowa.

Farmers' Tribune, Sioux City, Iowa.

Farm Stock Journal, Rochester, N. Y.

Fruit Grower, St. Joseph, Mo.

Farmers' Advocate, London, Ont.

Farmers' Review, Chicago.

Farm Stock and Home, Minneapolis, Minn.

Farm Progress.

Farm and Stock, St. Joseph, Mo.

Farm Life, Chicago.

Farm and Home.

Farmers' Digest.

Fruit Grower, St. Joseph, Mo.

Homestead, Des Moines, Ia.

Indiana Farmer, Indianapolis.

Kimball's Dairy Farmer, Waterloo.

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Missouri Agricultural College Farmer, Columbia, Mo.

Metropolitan and Rural Home.

Modern Farmer, St. Joseph.

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Modern Miller.
Minnesota and Dakota Farmer, Brookings, South Dakota.
Modern Farming, Richmond, Va.
Jewish Farmer.
Iowa Horticulture.
New Southwest, The, St. Louis, Mo.
National Farmer and Stock Grower, St. Louis.
New Zealand Dairyman, Wellington, N. Z.
Nebraska Farmer, Lincoln, Neb.
National Stockman and Farmer, Buffalo, or Chicago.
Nebraska Farm Journal, Lincoln, Neb.
Nut Grower, The.
Oklahoma Agriculturist, El Reno, Okla.
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Prairie Farmer, Chicago.
Planters' Journal, Memphis, Tenn.
Ohio Farmer, Cleveland, O.
Orange Judd Farmer, Chicago, Ill.
Ruralist, The, Sedalia, Mo.
Rural Home, New York, N. Y.
Rural New Yorker, N. Y.
Rural World.
Rural Advocate, Battle Creek, Mich.
Ranch News, Denver, Colo.
Strawberry, The, Three Rivers, Mich.
Southern Farm Magazine, Baltimore, Md.
Southern Agriculturist, Nashville, Tenn.
Successful Farming, Des Moines, Iowa.
Station Farm and Dairy, Sydney, N. S. W.
Surface Creek Champion, Cedaredge, Colo.
Southern Planter, The, Richmond, Va.
Texas Farmer, Dallas, Tex.
Wallace's Farmer, Des Moines, Iowa.

NEWSPAPERS:

Fort Morgan Times, Fort Morgan, Colo.
Illuminated World Life.
Mark Lane Express, London, England.
Palisade Tribune, The, Palisade, Colo.

EXCHANGES—Concluded.

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The Salt Lake Herald, Salt Lake, Utah.

WEATHER BUREAU:

Colorado Section.

Illinois Section.

New England Section.

New Mexico Section.

Oregon Section.

Wyoming Section.

REPORT OF THE ENTOMOLOGIST.

To the Director:

I beg to present herewith the annual report of the entomological section of the Experiment Station for the year now closing. The various projects for the year have been under the Hatch fund, the Adams fund, and the general fund and are referred to separately below.

HATCH FUND.

Project 1. Miscellaneous Insect Pests. This project was proposed to enable the section to give such attention as might be necessary to unusual or unexpected insect outbreaks that might occur during the year, both for the purpose of accumulating information concerning them and also for the purpose of testing methods of keeping the insects in check. There has been very little call for special work in this line during the year.

The Beet Plant Louse (Pemphigus betae) has occurred in unusual numbers in the Arkansas Valley and in a portion of the beet raising section in the northern part of the State, and considerable attention has been given to the louse for the purpose of determining some points in its life history, the extent of its injuries, both to the farmer and to the sugar companies, and possible means of prevention or remedy.

The Clover Louse (Aphis bakeri) has also been unusually numerous on the Western Slope and has attracted considerable attention in the orchards. We have succeeded in working out its life history quite fully, and also the remedies that should be applied to keep it under control. The life history of this louse was very imperfectly known before.

Two of the vegetable feeding mites, commonly known as the red spider and the brown mite, have also been quite destructive this year, especially to raspberry bushes on the Western Slope. Mr. Weldon gave some special attention to a test of remedies for destruction of the mites and met with good success.

While the work upon the lice here mentioned might also be placed under the Adams fund project, I am placing it here because of the unusual outbreaks of these insects calling for special attention.

Project 2. Collecting and Rearing Insects. Nearly all the work under this project during the past year has been confined to the plant lice and their enemies. A small number of other insects have been taken as good opportunities presented themselves, all of which have been properly labeled and placed in the insect collection.

We now have one of the largest collections of plant lice in the West, and perhaps the largest collection of western plant lice to be found anywhere, including close to 1,000 balsam mounts and a somewhat larger number of alcoholic vials. These lice are in greater part determined to species and systematically arranged for study.

Project 5. Experimental Orchard. The objects in putting out an experimental orchard were: First, to have a good number of orchard trees that might be used in an experimental way for the purpose of rearing insects and testing various methods for their control. The trees have done well this year; we have infested them quite thoroughly with the green aphis and the woolly aphis for experimental purposes, and have succeeded in rearing the sexual forms and obtaining a good number of eggs of the latter species.

Project 7. The Potato Flea Beetle. The work under this project is a continuation of work that has been carried on by Professor Johnson for the past two or three years upon this insect. Professor Johnson hoped to be able this year to complete his observations upon the life history of the insect and to test a few remedies in a large way in the field. The testing of remedies was rendered impossible so far as obtaining satisfactory results is concerned, because of a very small number of the insects in the fields which he had chosen for the experiments.

ADAMS FUND.

Project 3. Plant Lice Investigations. The major part of the work under this investigation has been carried on in the vicinity of Fort Collins, though it has been necessary to make numerous trips into different portions of the State, and Mr. Weldon has also given this project a considerable share of his time on the Western Slope, especially to the collecting and rearing of the plant lice. Mr. Urbahns, while employed by this section, gave much of his time to the rearing of the parasitic and predacious enemies of the plant lice. Miss Palmer, aside from making numerous drawings in color and also in ink, has devoted considerable time to the study of the life habits of a few of our more common species of lady beetles, and has obtained some very interesting results.

The plant lice more especially studied are the green apple aphis *(Aphis pomi)*, the woolly apple aphis *(Schizoneura lanigera)*, the melon louse *(Aphis gossypii)*, the green peach aphis *(Myzus persicae)* and the clover aphis *(Aphis bakeri)*.

In addition to the work upon the species above mentioned we have also collected extensively, taking species that might be found either upon cultivated or native plants or weeds. This work we have found very important, as we often come upon one of the well known pests of some cultivated plant that is spending a portion of its year upon some unexpected weed or cultivated plant.

As a result of the plant louse studies, Bulletins 133 and 134 have been published, as well as several articles of a more technical nature, in the entomological journals. The more we do on this project, the larger becomes the field for future study and experimentation. So we hope to continue it for some years to come.

SPECIAL FUND.

Project 4.—Codling Moth Investigations. Work was planned both for the eastern and western slope for the purpose of determining more fully some points in the insect's life habits, and more especially to determine the proportions of poison to use in arsenical sprays for the destruction of the larvae before they enter the apples. The object in this part of the work was to determine the smallest number of applications and the weakest strengths of poisons that could be successfully used for the purpose of avoiding unduly filling the soil with arsenic. On account of the spring freezes, which practically destroyed all the fruit on the eastern slope and which destroyed a large portion of it upon the western slope, this project was seriously interfered with. Mr. Weldon, however, carried through a series of experiments at Paonia and has obtained very satisfactory results, which are given in his report of this year. The project should be continued another year and should be carried through upon a larger scale.

Project 6.—West Slope Field Work. This project was proposed for the purpose of covering the general work that would be done chiefly by Mr. Weldon in his efforts to instruct the fruit-growers as to the best methods of controlling their orchard pests. This work is detailed quite fully in Mr. Weldon's report for the year. The writer has also made several visits to the western slope for the purpose of advising in this work both with Mr. Weldon and Mr. Whipple and the horticultural inspectors. I believe that much benefit to the fruit-growers has been derived from this work and I think it very important that it should be continued for many years to come.

Very respectfully submitted,

C. P. GILLETTE.

SUMMARY OF ANNUAL REPORT OF FIELD ENTOMOLOGIST.

Delta, Colorado.

Introduction.

It was found necessary to confine the work, more or less, to certain orchards, and on that account not so many were visited as we would have liked. Some little hard feeling may have been occasioned because of certain orchards not having been visited. An orchard was always visited upon request of the owner, so if any one was neglected they alone deserve the brunt of blame.

GENERAL CONDITION OF ORCHARD WITH REFERENCE TO INSECT PESTS.

Improved methods of spraying are generally practiced.

Parasitic and predacious enemies have been doing good work in the orchards and their attack, along with ordinary care in spraying by the owner of fruit tracts, leaves little room to worry over future prospects in controlling insect pests.

It is true in Colorado, as elsewhere in fruit sections, that the grower of a few trees is more troubled with insect pests than the man with a commercial orchard. The latter, depending on his trees for a livelihood, realizes the necessity of proper care. There are many men who should be compelled to spray their trees.

There is probably no possibility of ever exterminating some of our more serious insect pests, but they can be kept in check, so that little harm will result from their attack.

DIFFERENT PHASES OF WORK UNDERTAKEN.

1. Examination of Orchards.
2. Study of Spraying Methods.
3. Experiments with Insecticides.
4. Insect Pests of Orchards.
5. Control, natural and artificial.
6. Hindrances to natural control.

EXAMINATION OF ORCHARDS.

In the neighborhood of 100 orchards were visited and general conditions noted. Any unusual conditions, whether caused by insects or otherwise were always studied, and visits to such orchards as had problems of a Horticultural nature were on different occasions made in company with Mr. Whipple, Field Horticulturist at Grand Junction.

STUDY OF SPRAYING METHODS.

Probably in no other fruit section is spraying so generally practiced, and with such good results.

Apples are secured from 95 to 99 per cent. free of worms, through the use of thorough spraying methods. Other pests are not seriously dreaded as a rule.

Arsenate of lead is almost exclusively used in controlling the codling moth.

On account of the Arsenical poisoning of trees care must be exercised in its future use.

There are at least four principal ways whereby good may be obtained. 1—Arsenate of lead must not be used in such large quantities. 2—Trees must not be sprayed more than twice in a season. 3—Nozzle must not be held so that spray will be directed at trunk and larger limbs which will carry it to the ground. 4—Spraying must be done thoroughly without allowing excessive drip from the trees.

Spraying for aphis is not attended with the same dangers that beset one in spraying for the codling moth. There are two sprays now more generally used than any others in the control of aphis, viz.: "Lime and sulphur" and "Black leaf." The former is an excellent dormant spray to kill the eggs of all kinds of aphis that lay them upon the trees, the latter will kill every aphid touched in spraying when used at a strength of 1-75.

Soluble oils, kerosene emulsion, whale oil soap, etc., are giving place to the above sprays.

More failures in controlling aphis are due to careless work than to all other causes.

INSECT PESTS OF ORCHARD TREES.

The following is a list of pests found on orchard trees the past summer: Peach twig borer (Anarsia lineatella), Grain aphis (Aphis avenea), Clover aphis (Aphis bakeri), Cherry aphis (Aphis cerasi), Sweet clover aphis (Aphis medicaginis), Black peach aphis (Aphis persicae niger), Green apple aphis (Aphis pomi), Howard scale (Aspidiotus howardi), Climbing cutworms, Codling moth (Codia pomonella), Mealy bugs (Dactylopius sp.), Cherry slug (Eriocampoides limacina), Lecanium scale (Eulecanium cerasifex), Peach scale (Eulecanium nigrofasciatum), Plum aphis (Hyalopteris arundinus), Red spiders (Tetranychussp), Green peach aphis (Myzus persicae), Snout beetles (Cleonus collaris), Pea aphis (Macrosiphum pisi), Woolly aphis (Schizoneura lanigera), Brown mite (Bryobia sp.).

CONTROL OF INSECT PESTS.

Natural control. Lace-winged flies, Syrphus flies, and Ladybird beetles, along with other predacious and parasitic enemies, did excellent work in controlling aphis in many orchards.

Artificial control. Spraying is the most important, and practically the only artificial method used. Careful attention to details, such as cleaning up rubbish, etc., is often a great help.

Barriers to control. Many parasites work on both Syrphus and Lace-winged flies. Spraying also kills many beneficial insects, but not in proportion to the number of destructive.

EXPERIMENTS.

First. Experiments to determine the least strength of the Arsenate of lead that can be used effectively, and with the least number of applications. Two strengths were used in the regular experiment, 2 pounds per 100 gallons and 3 pounds per 100 gallons. Eighty-five trees were sprayed with these strengths at an interval of eleven days. Part of the rest of the orchard was sprayed by the manager, with 4½ pounds per 100 gallons making two applications. The second began ten days after the first. The rest of the orchard was sprayed with the same strength, but received a third spraying about thirty days after the first. The purpose of the first two sprayings was to fill the calyx cups. One spraying would have been as good as two provided the blossoms had come out with a little more regularity.

Counts of 15,469 Ben Davis and Jonathan apples showed the following results:

2 pounds per 100 gallons, 85% free from worms.

3 pounds per 100 gallons, 88% free from worms.

4½ pounds per 100 gallons, two sprayings, 95% free from worms.

4½ per 100 gallons, three sprayings, 97% free from worms.

Check tree, Ben Davis, 70% free from worms.

Second. Experiments to determine the effect of the different sprays upon the eggs of the Green apple aphis.

This experiment is still under way and we do not feel justified in drawing any definite conclusion from the work already done.

Three. Experiments to determine the effect of the "Black leaf" upon Red spiders.

This experiment indicated that "Black leaf" is an effective remedy for these pests. It was not found to be effective, however, in killing the eggs at the strength tried, 1-65 to 1-70.

GEO. P. WELDON.

REPORT OF CHEMICAL SECTION.

To the Director:

I have the honor to report that during the period elapsing since our last published report the work of the chemical section has consisted of those lines of investigation which had previously received your approval.

The portions of these projects completed within this period have been presented in the bulletins offered for publication by this section, i. e., Bulletins 124, 125, 129, 131, 132 and 135.

Bulletins No. 124 and 125 present the results of our study of the composition and comparative values of some of our Colorado hays, i. e., alfalfa hay, timothy hay, native hay, corn fodder, sorghum and hay made from one of our native saltbushes, *Atriplex argentea*. Bulletin No. 129, by Mr. Alford, presents the results of our study of the commercial methods of extracting and purifying beeswax. No. 131 treats of the arsenical poisoning of fruit trees. No. 132 of the destruction of concrete by alkali or alkaline waters, and No. 135 presents those features of our study of the Australian saltbush, *Atriplex semibaccata*, as we deem of general interest and advantage to the people of our State, in particular to those who have taken up their residences in sections of the State where the sufficiency of the annual rainfall for the production of good crops is usually a little uncertain and where a forage plant which will produce a good yield with a small amount of water is desirable. This section has presented Bulletin No. 135, in the hope that it may prove of immediate value to such sections of our State, but it has a further object; it presents the cultural and general data concerning the hay made from this saltbush which serve as a basis for its further study on these lines presented in Bulletins 39 and 124. It bears the same relation to a bulletin which I shall present in the future that No. 93 presents to No. 124.

The arsenical poisoning of fruit trees and the destruction of concrete by "alkali" are special features of our alkali problem, but are of such considerable and immediate importance that I deemed it justifiable to present these subjects by themselves.

This section has begun no new work, because the subjects already approved will engage our attention for some time to come.

The study of the changes in the waters of the Rio Grande and their relations to the soil conditions of the San Luis Valley has been continued and will probably be completed within the next year. The season of 1907 was unfavorable for the prose-

cution of this work, owing to the exceptionally high water i the river. We were, at least, afraid to proceed with the wor during this season, 1907, because we feared that the unusu amount of water in the river would obscure the factors whic we wished to determine. It seems now that we might hav proceeded with safety, but we did not know this at the tim and it required considerable proof to convince us that such wa really the case.

The study of the composition of fodders and their compa ative values has been advanced since the publication of Bullet No. 124, by the study of the Australian saltbush, atriplex sem baccata, on which the analytical work has been completed an will be ready for publication sometime during the coming sum mer.

The general problems of alkalies in Colorado is bein studied concurrently with our other work, but I am desirous bringing it to an end at the earliest possible date, which, how ever, I can not hope to do very soon.

The subject of mountain irrigation and the composition the hay grown under this system combines two lines of wor previously studied separately, i. e., the changes of the irrigati waters and the composition and comparative value of fodde I hope to actively begin this work during the next irrigati season. While this work forms a single study it will evident have to be treated from these two standpoints, which it may advisable to treat separately, but this is a matter for furth determination.

The work done on the study of the deterioration of manu under our Colorado conditions is being put into shape for pu lication by Mr. Douglass, but he is so continuously engaged other work that it will be sometime before he can complete

The systematic work planned for this section is more tha sufficient to keep all of its force busy for at least two years, there is no opportunity for doing miscellaneous work, for whi there continues to be many applications, especially for analys of soils and waters. Sometimes these miscellaneous matte are of general interest and even important, but usually they a not.

The equipment and appointments of our laboratory a adequate to our present needs.

Respectfully submitted,

WM. P. HEADDEN.

Fort Collins, Colo., Nov. 1, 1908.

'o the Director:

On account of the demands upon my time, with which you re familiar, my part in Experiment Station work has not been ushed so vigorously as I could have wished; however, some rogress has been made. But in the subsection the usual good ork has been accomplished, as the reports from the men will ow.

Taking up the schedule of work as outlined last spring, we nd the work in the following condition:

Red Raspberry Industry, not yet written up.

Tomato Blight. Good results in controlling this disease were cured by growing the plants in sterilized soil. Almost no blight peared in plants so grown. Further experiments desirable.

Raspberry Yellows. Considerable laboratory work has been ne with this disease; a fungus was isolated and inoculation ex eriments show that it is capable of attacking raspberry canes. nother season will be required in which to complete the work.

Pea Breeding. This work is finished so far as the present periments are concerned. A variety of suitable size has been cured, but whether it will meet the requirements of the canner n only be determined by an extensive field test.

The subjects of The Orchard Plant; Location; Site and Soil, d History and Development of the Fruit Industry have been itten.

The Cold Storage investigation with vegetables has just en started. Results will not be secured until late in the nter.

Bean Breeding experiments, by Mr. Paull, were satisfactorily gun, but several years must elapse before results are secured.

The Strawberry Industry has been written by Mr. Longyear d is about ready for publication. Mr. Longyear has spent ch time in studying the cause of the so-called black root of the awberry plant. A much longer time will be required to com te the work.

Mention has been made in former reports of a bacterial blight alfalfa. Since alfalfa is the basis of Colorado agriculture, and s disease is becoming more and more of a menace, it was ught best to devote considerable energy to determining the ture of the disease and the method of control, if possible. Ac dingly, a bacteriologist, Professor W. G. Sackett, formerly of University of Chicago, was secured to take up this work under

the Adams fund. Mr. Sackett has already got the life history of the organism well in hand and is making rapid progress with the work.

The potato investigations are proceeding satisfactorily, and, as a direct result of this, the output of the State will be increased this year many carloads. The principal work with potatoes is along the line of building up a better and more stable class of varieties by seed selection, as well as the investigation of potato diseases.

The fruit investigations continue to be satisfactory to all concerned. Mr. Whipple has the practical subjects, as outlined in his schedule, written and about ready for publication. These are as follows: The Grape Industry; The Dewberry Industry; Grafting; Packing; Fruit Buds and Pruning Mature Trees.

Respectfully submitted,

W. PADDOCK.

ANNUAL REPORT OF THE FIELD HORTICULTURIST.

To The Director:

Report of the Field Horticulturist.

During the year a total of nearly seven weeks of my time has been devoted to extension work in different parts of the State, four weeks to Short Course work and three weeks to one-day summer meetings. The rest of my time has been given to special lines of work connected with this office, trips to other fruit districts of the State, and general field work. Much of the time, however, has been devoted to work in Mesa county.

The special lines of work outlined at the beginning of the year by Prof. Paddock and myself consisted of investigations and experimental work upon the following subjects:

Pruning Mature Fruit Trees, Picking and Packing Fruit, Top-Grafting, Dewberry Growing, Grape Growing, Root Rots of Fruit Trees, Crossing Fruits, Bloom Notes, and Fruit Buds and Fruit-Bearing Habits. In addition to this, some special work, of a nature that could not well be anticipated, has been taken up throughout the year. One of interest has been the effect of frost upon bloom and fruit and the value of second-crop bloom considered from the standpoint of fruit production. Another line of investigation has been the effect of whitewashing peach trees, in Coto, as a means of retarding the blooming season.

The work along the line of pruning mature trees has been largely observations in the field, the effects of the different methods of pruning as practiced. The manuscript for a bulletin is now prepared.

The object of the work in picking and packing fruit is the preparation of a bulletin for the instruction of fruit growers in the best methods of picking and packing fruit. The information has been gathered by observations in the field, with suggestions for improvement on present methods gleaned from the experiences of other sections.

The manuscript for a bulletin upon top-working fruit trees has been prepared and is intended to give information as to methods of top-working and when it is advisable.

The work upon the subject of root rots has been practically dropped, as it appears to come under the work of the Department of Chemistry. There are cases where the death of roots is not due to arsenical poisoning, but they are scattered and probably result from a variety of causes.

The object of the work in crossing fruit has been to obtai crosses between our common varieties of apples and the seedles apple, in hopes of getting a seedless seedling of merit. No progres has been made on account of the late killing frosts of the pas two seasons.

Notes have been gathered upon the blooming season of th different varieties of apple and pear, with a view of ascertainin which varieties are suitable for interplanting to secure cross fertilization. The observations have shown considerable varia tion; even the blooming seasons of two varieties do not alway bear the same relationship to each other in different seasons.

The dewberry industry has been studied in the best dewberr sections of the State, and the manuscript for a bulletin has bee prepared upon the subject.

After a thorough study of the condition of the grape industr in the State the manuscript for a bulletin is now being prepared Methods of handling vineyards are not well understood and i is hoped that the growers may be encouraged to use better meth ods in growing grapes, especially to adopt better methods o pruning.

The information gathered upon fruit-buds and fruit-bearin habits has been incorporated in the manuscript for the bulleti on pruning.

The experiments undertaken to demonstrate the value o white-washing peach trees as a means of prolonging the dorman season showed very little benefit derived from the treatment The trees were retarded only slightly, if any.

Observations upon the effect of frost upon bloom and frui and the value of second-crop bloom have been assembled in manuscript for publication as a bulletin, if worthy, or to be kep as a matter of record.

Work spoken of as general field work consists of answerin calls for information upon the care of particular orchards o to give solicited suggestions upon the treatment of the orchar to overcome difficulties.

Respectfully submitted,

O. B. WHIPPLE,
Field Horticulturist.

REPORT OF THE BACTERIOLOGIST.

1908.

Beginning with May 1, 1908, a new line of work was introduced into the Experiment Station. Previous to that time only a limited amount of investigation work along bacteriological lines had been carried on, and with the increasing importance of the subject and with the new problems which were continually arising, it seemed advisable to take up more extensive as well as intensive studies in this field. Accordingly a laboratory for bacteriological research was established under the Adams act. This laboratory has been fully equipped with the most modern appliances for accurate work and will be in perfect running order in the very near future. While considerable time has been consumed with the furnishing, equipping and arranging of these new quarters, we have, nevertheless, been able to carry on some investigation work at the same time. Unfortunately not much laboratory work was accomplished the first two months, owing to lack of equipment, but since then our undertakings have been more fruitful.

The most important problem which has claimed our attention is a bacterial disease of alfalfa. We have been able to isolate the causal organism and to reproduce the disease on alfalfa cuttings under laboratory conditions with a reasonable degree of certainty. While the stems inoculated with laboratory cultures resemble closely those found in the field, they do not have exactly the same appearance as those naturally infested. This is undoubtedly due to the difference in outdoor and laboratory conditions.

The morphological and cultural reactions of the organism are now being worked out for the purpose of identification, and during the winter season it is expected to continue the inoculations upon greenhouse material and in the spring to carry this phase of the work into the field. Field inoculations this season were impracticable, owing to the late date at which the causal organism was isolated.

Greenhouse experiments are now being carried on with the view to ascertaining, if possible, how the natural infection of the plants occurs. Next spring it is expected to spend a large amount of time in the field where the disease occurs naturally, with the purpose of studying further the methods of natural

infection as well as to test out the pure cultures of the organism isolated by inoculations under field conditions.

Of the twenty-six different varieties of alfalfa which were planted on infested land at Gypsum, Colorado, over a year ago with the idea of obtaining, if possible, a disease resistant plant there is one variety and possibly two which look very promising. This variety work will be continued another season, with the hope that we may be able to solve the economic side of this question in this manner. Respectfully submitted.

WALTER SACKETT,
Bacteriologist.

POTATO INVESTIGATIONS.

The work on the Colorado potato industry has been carried n during the past year along practically the same lines as the ear previous.

Varieties of potatoes secured from the United States Depart- ient of Agriculture, with some others from this State, were again lanted on the E. R. Bliss ranch, near Greeley. The object of rowing these varieties at Greeley was partly to test them for ield and general desirability, as compared with the standard arieties grown there, and partly to secure, if possible, a variety iat will be resistant to the soil diseases that frequently attack otatoes in this State. Notes were kept as to habit of growth, ize of plant, time of maturity, yield, etc., as compared with the tandard varieties.

Only a few of the seventy varieties have given promise of eing able to compete with the "Pearl" as market varieties.

Very little trouble from the soil diseases was had with any of he varieties, so no data as to resistance were obtained.

A plot of about three acres of potatoes was grown on the ollege land at Fort Collins. In this field experiments with ifferent treatments of seed potatoes, methods of preparing seed nd cultural methods were conducted.

This field was also used for a study of the diseases and insect ests. So much time has been spent in promoting the industry nd advising growers in other parts of the State that much sys- ematic study of the diseases has not been possible.

The survey of the potato-growing districts of the State has een carried on for the most part in connection with the institute ork. During the season visits have been made to the valleys f the Eagle, Crystal, Roaring Fork, Grand and Uncompahgre ivers, the San Luis valley and to La Plata and Montezuma coun- ies.

In promoting the industry and instructing the growers in egard to varieties, cultural methods, etc., talks have been made t sixty-nine places since the previous report.

Probably the most important work is that being carried on n co-operation with the growers in various parts of the State. he aim in this is the improvement in yields and quality of otatoes from planting seed that has been hand selected in the eld.

Colorado is producing as good, or better, quality of potatoes nan any state in the United States. The yield per acre was reater last year (United States Department of Agriculture tatistics) than any state except Wyoming. The cost of produc-

tion per unit is less than in other states. There is sufficient un developed land in the State adapted to potato culture to produc three or four times the present total output. This year Colorad will produce about 20 per cent. more potatoes than previous years The value will probably reach six million dollars, or about twic that of all the fruit of the State.

If the growth of the industry in the State continues nor mally, Colorado ought in a few years to be one of the leadin potato producing states of America.

CABBAGE INVESTIGATIONS.

Along with the potato investigation at Greeley data hav been secured on cabbage growing in Colorado. This data hav been secured for the purpose of writing up the industry in bull tin form for the benefit of the new comers to the State.

E. R. BENNETT.

Bulletin 116 June, 1906

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

THE COTTONY MAPLE SCALE

By

S. A. JOHNSON

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1906

THE AGRICULTURAL EXPERIMENT STATION

FORT COLLINS, COLORADO

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The Cottony Maple Scale

Pulvinaria innumerabilis Rathvon.

BY S. ARTHUR JOHNSON.

The past few years have witnessed a recurrence of the cottony naple scale in injurious numbers in several parts of the United States. The present outbreak has brought about a greater activity in the use of remedial measures than ever before, and though the control of the nsect has not yet been accomplished, sufficient has been learned to point the way. It is the purpose of this bulletin to gather the important points of economic literature and the series of experiments and bservations made at this station so that what is now widely scattered nay be immediately available to those who need the information.

The most bitter complaints of injury at all times appear to have ome from places where the maple tree is cultivated for shade. The easons for this are not positively known, but we are tempted to peculate that it is due to the artificial conditions under which the rees are placed. Under forest conditions the insect appears to be kept n check by its natural enemies, which doubtless, find shelter and protection in their native haunts which are denied them among trees lanted on private grounds and in parks.

Thus far the remedies and their application are rather expensive, ut are amply justified when we consider that a beautiful tree is the ork of years and cannot readily be replaced except by a repetition of he long years of waiting.

SYNONOMY

Riley in the report of the Commissioner of Agriculture for 1884, as summarized the synonomy of the species to that date and to that rticle I am chiefly indebted for this paragraph. The insect was first escribed as *Coccus innumerabilis* by Dr. S. S. Rathvon of Lancaster, a., in the "Pennsylvania Farm Journal" (Vol. IV, pp. 256-258, Aug., 854.) Five years later, Dr. Asa Fitch redescribed it in the "Transctions of the New York State Agricultural Society" (Vol. XIX, pp. 75-776) under the name of *Lecanium acericorticis*. A third descripon was made by Walsh and Riley in the American Entomologist Vol. I, p. 14, 1869) as *Lecanium acericola*, the previous descriptions. aving been overlooked. A closely allied form on the osage orange, eceived from these last writers the name *L. macluræ*. After the pubcation of the names given by Riley and Walsh, Dr. Rathvon called ne attention of these entomologists to his description and subsequent

correspondence showed that the species were identical. Glover in 1877 revived Fitch's name of *Lecanium acericorticis* which had been overlooked up to that time.

While this portion of the problem of synonomy was being thrashed out, Mr. J. Duncan Putnam was making a careful study of the life history. Four articles came from his pen. The first three were printed under Walsh and Riley's name of *Lecanium acericola.* (*). The fourth article is a very thorough study of the life history covering some fifty pages of text and accompanied by two plates. (**). In it the author, at the suggestion of Prof. Riley, restored the original name of *innumerabilis* and transferred the species to the genus *Pulvinaria.*

While this discussion appeared to clear the field to the point given it was far from doing so. It appears that Walsh and Riley, Putnam and other writers had collectively confused at least three distinct species. This state of affairs was discovered by Dr. Howard and unraveled by him in 1900. (***). In their original article Walsh and Riley had really included two species in both the cut and description; one in which the female reached the adult stage on the twigs and corresponds to *P. innumerabilis* Rathv., and a second which matures on the leaves and receives the name *P. acericola* W. & R. A third form, *P. maclura* occurring on osage orange had been considered synonymous with *P. innumerabilis* by some writers. Prof. Cockerell has since examined this and considers it entirely distinct. To the western form the latter writer has given the varietal name of *occidentalis.* If this should prove to be a distinct species it will raise again the question of its introduction. Some of the scales found on food plants widely separated from maple may yet be found to be distinct from *P. innumerabilis.*

DISTRIBUTION

This insect is a native of the United States and our literature dates from its discovery by Dr. S. S. Rathvon in Pennsylvania. It has, however, long been widely distributed over the country. (See Fig. 1.) Mr. Sanders calls attention to the fact that the insect is preeminently an inhabitant of the upper austral zone, though sometimes it penetrates the transitional. In other words it is found in the middle zone of states extending from the Atlantic coast to the Rocky mountains. Outside of this range it is found northward in New York, Michigan and Wisconsin. To the south, branches appear to follow the highlands into Tennessee, Georgia and North Carolina and at the western extremity into Texas. Mr. Gossard found it on pecans in Florida, where in some cases, it was doing considerable injury. In the western states the pest is reported from Washington, Oregon, Idaho and California (both northern and southern) where it is believed to be an introduced insect.

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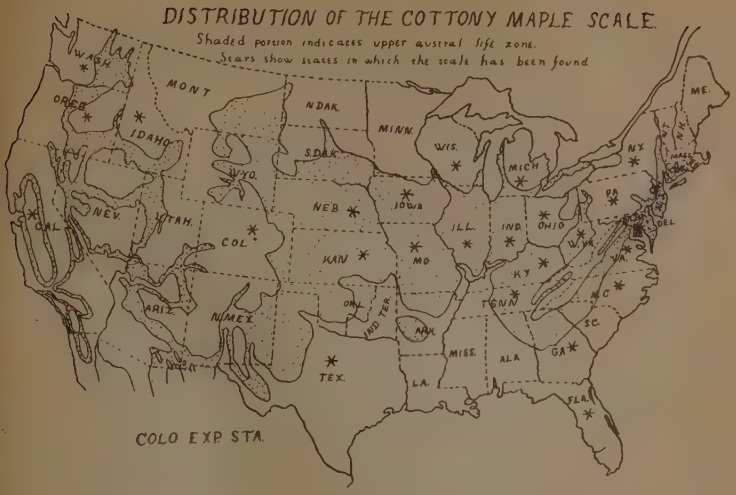
*(Prof. Davenport Academy of Nat. Sci., Vol. I., p. 37, 1876; Davenport Daily Gazette, June 5, 1877; Trans. Iowa Horticultural Soc., 1877, pp. 317-324.)

**(Proceedings Davenport Acad. Nat. Sci., Vol. II, Part V., pp. 297-347, 1879.)

***(U. S. Dept. Agr. Division of Entomology, Bul. 22, n. s.)



FOOD PLANTS

The host plants of this species are very widely distributed among trees, shrubs and vines. Sanders states that the list comprises forty-seven varieties and species. But few of these are of economic importance for they are seldom badly infested. The greatest sufferer is the food plant from which the insect receives its name, the soft or silver leaved maple (*Acer saccarinum*). Next in importance are the box elder (*Acer negundo*), black locust and elm. It has also been found in large numbers on pawpaw in Illinois. Mr. H. E. Weed gives as less seriously affected, linden (*Telia*), Virginia creeper (*Ampelopsis quinquifolia*), bittersweet (*Celastrus scandens*), sumac (*Rhus*), grape (*Vitis*), and willow. Together with some of the above, other writers have mentioned poplar, beech, hawthorne, sycamore, hackberry, mulberry, poison ivy, rose, basswood, and ash. In Georgia the oak is reported as being seriously affected. Singularly, sugar and Norway maples seem to be but little injured even where they are surrounded by badly infested host plants.

Among fruit trees, the pear is the greatest sufferer. Apple, plum, peach, currant and gooseberry are also sometimes attacked.

Some plants serve as hosts during the summer, but do not appear to winter over the insect. A list given by Mr. Weed includes *Spiræa Van Houtenii, S. arguta, S. prunifolia, Philadelphus grandiflorus, P. coronarius, Cornus mascula, C. siberica, C. stolonifera, Ribes aureum, R. sanguineum, Hydrangea, Rudbeckia, Syringa* and *Vibernum.*

The western form, which is known as *occidentalis*, appears to be fastidious in its tastes or has imbibed the western spirit of a desire

for new things, for Mr. Piper states that it is not found abundantly on the native maples, but infests currant, gooseberry, plum, pear, hawthorne, mountain ash, Lombardy poplar, weeping willow, currants (*Ribes sanguinum*), and species of willow (*Salix flavescens* and *S. lanadra*).

A careful study of the forms on all of these food plants has not been made and it will be wise to make a mental reservation as to the identity of the species in some cases until further evidence is forthcoming.

The economic history of the insect shows that its destructive abundance in certain localities is periodic. The data at hand fail to show that this periodicity is amenable to any law, though there have been two periods of general abundance over its range. The statement has been widely circulated that the scale is seldom injuriously abundant two years in succession, but this has been proved to be untrue within the past few years in widely separated localities. In the early eighties there was a general visitation of the pest and Dr. Forbes made a number of preliminary experiments looking toward control. On this occasion the insects appeared in great abundance in 1880 and 1884, subsiding to insignificant numbers during the intervening years. A second scourge occurred during the past five years and is reported by Mr. Chittenden as being more generally abundant over its range than at any previous year. The city parks of Denver and Chicago seem to be the storm centers. In the latter place the lower limbs of the silver maples have been killed in great numbers, leaving the trees unshapely in appearance. Many hundreds of trees have been killed outright. In Denver the destruction has been, perhaps, less severe, but weeks were spent cleaning dead limbs out of the parks and many trees along the more crowded streets have been injured to such an extent that they are practically worthless.

LIFE HISTORY

When the sap begins to flow in the food plant the young hibernating females begin to suck up the fluid rapidly and to grow. In a few weeks they have increased their size about four times. At this stage the scales, which before may have been unnoticed because of their flat position on the bark and similarity to it in color, become suddenly conspicuous on account of the white cottony mass of wax which is thrust out from under the posterior end. This material is, composed of wax threads spun from the ventral glands of the animal, especially those located on the margins, and serves as an ovisac. (See Fig. 2.) The quantity is enormous for the size of the insect. The extrusion of it gradually raises her body from its flat position on the twig until it stands out at an angle of some sixty degrees or even vertically. During this period the egg laying proceeds. This takes place at different times in different localities and seasons, varying with the temperature and in some cases with the food plants. In Florida when this scale appears on pecans, Gossard states that the ovisacs become conspicuous during April and May. In most other places they appear in May or June.

The egg laying extends over almost the entire period of cotton secretion, but is most active during June. In many cases it doubtless begins in May and extends, in some cases at least, into July.

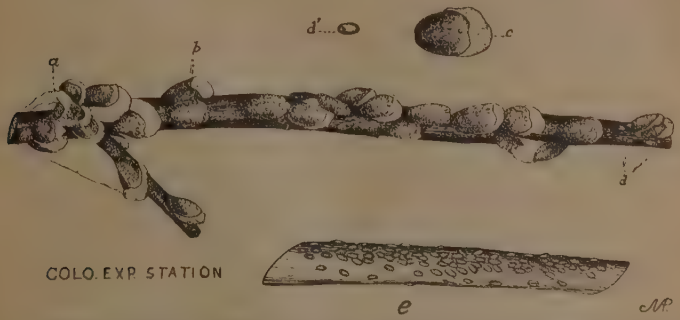


FIG. 2. Females of the cottony maple scale: a, ovisac opened to show eggs; b, females with cottony mass partly secreted; c, slightly enlarged female; d, parasitized winter form; d' the same slightly enlarged; e, hibernating winter form. All except c and d' natural size. (Drawn by Miss M. A. Palmer).

The eggs are tiny oval spheroids, pale cream in color. The number as given by the older entomologists is from one to two thousand. These figures are probably somewhat too large and more recent writers have reduced the estimate. Cotton mentions from three hundred to one thousand and Sanders says that the number may reach fifteen hundred.

The egg hatching likewise consumes considerable time. To quote from Dr. Howard on observations made in Washington, D. C.:

"The young lice hatch early in summer, usually in June, but occassionally at least as early as May 22. The hatching period usually extends on into early July, but may last until August."

Seasonal influences appear to bear considerable weight. Mr. H. E. Weed makes the following note of conditions in Chicago in 1904:

"During the past summer the eggs were slow in hatching, as the season was very backward. Up to June 25, practically no eggs were hatched. Two quite warm days occurred about July 10, and this served to bring them out."

In the visitation of 1884, Dr. Forbes states that the young were abundant by the middle of June, but in some localities 25 per cent of the eggs were not hatched on July 19. Colorado observations give the following: "June 22, 1901. Scales from Delta and Montrose were full of eggs, but no lice hatching yet." "July 2, 1902. All hatched and beginning to scatter from twigs of soft maple from Colorado Springs." "Denver, June 10, 1904. The scales are just beginning to raise and expose the cottony secretion of the louse. I find on examining these scales that a few eggs have already been deposited." The foregoing notes were made by Prof. Gillette.

On July 15, 1905, I visited the parks of Denver and found that most of the eggs had already hatched. In fact, unhatched clusters were very difficult to find. There appears to be an unexplained phenomena in that the eggs laid on some trees hatch at times differing

from their neighbors. Young lice have been known to appear upon box elder before maple.

The newly hatched young remain a day or two in the ovisac and then migrate to the leaves where they attach themselves to the ribs or, rarely, to the young twigs. In doing this they prefer the under sides and larvæ so situated appear to grow more rapidly than those otherwise located. In times of serious infestation these locations soon become preempted and the young swarm over every green thing within a short radius of their home. It is in these cases that the summer food plants serve as hosts. On some of these they seem to prosper fairly well. Dr. Forbes found that the males reached maturity on strawberry plants, and, as an isolated maple tree which had been thoroughly treated during the summer was reinfested in the fall, concluded that the females had found their way back from temporary food plants.

Shortly after the young begin to feed a delicate waxy scale forms over the back.

The first molt occurs in from three to four weeks from the hatching of the egg. It was observed in Washington as early as June 10. At this time the insects are about twice their size at hatching.

After this molt the differences in the sexes is observable. "The males grow more slender and soon cease to increase in size, covering themselves with a thin coating of wax." At this stage, according to Howard, the second molt takes place beneath the scale and a propupal stage occurs. (See Fig. 3.)

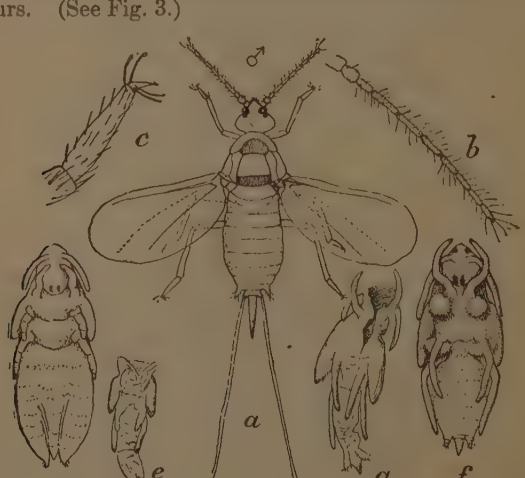


FIG. 3. PULVINARIA IMMUMERABILIS: a, adult male; b, antennæ of same; c, leg of same; d, second stage of pupa; e, cast skin of same; f, true pupa; g, cast skin of same All greatly enlarged, b and c still more enlarged. (Howard Bul. 22, Div. of Ento m., U. S. Dept. Agr.)

"In a few days the pupa casts its skin and assumes the true pupa form, which, during its earlier stages is a pale green color, becoming dark flesh color at a later date." "The antennæ which up to this time were seven-jointed, had now become eight-jointed. There seemed to be two propupa stages. After casting the second skin,

the male larvæ looses its rostrum and its anal cleft, although the wing pads have not yet developed; the antennæ are stout and laid backward without perceptible joints, and that end of the body is furnished with two long conical tubercules. After the third skin is cast, an apparent propupal stage is found which bears wing pads reaching to the abdomen; the claw of the tibia is lost, and between the posterior tubercles has appeared a stout, rudimentary style." Howard. "A long pair of wax filaments is secreted from the anal extremity and these continue to grow during the life of the insect. It is the protrusion of these filaments from beneath the waxy scale which indicates the approaching exclusion of the male."—Riley.

The changes in the female scales are less conspicuous but nevertheless characteristic. After the first molt they broaden posteriorly and have a slight dorsal carina. When the males appear, they have undergone a second molt and changed from pale yellow to light green and are marked with a brown dorsal stripe the whole length of the body.

The males appear during the latter part of August or first of September, copulate with the females in a few days and die.

The summer injuries are most conspicuous on the leaves. Dr. Forbes states that in 1884 many trees at Bloomington, Ill., had lost a considerable portion of their leaves by August 16, and the others were blackened and dwarfed, giving the branches a bare and unthrifty look.

In early October the gravid females desert the leaves and find places for hibernation on the branches and twigs. Immense numbers drop to the ground with the falling leaves which results in a great loss of life from the inability of many to find their way back. The position sought is the under sides of the twigs and small branches, the lower branches of the tree being usually most densely populated. Many locate around the crotches and on the upper sides of the twigs. The scales are still quite flat and about one fourth grown, varying from one and one half to two and one half millimeters in length. The position assumed on the twig is more often lengthwise than crosswise and the number may be as great as the bark will accomodate. (See Fig. 2 c.) The color changes at this time from a light green to light brown. It is very doubtful if any nourishment is taken from this time till the spring activities begin. The mortality, outside of parasitism, during this period is considerable and varies greatly with different twigs and trees. The check twigs counted from trees in Denver showed this to vary from twenty-five to sixty-two per cent.

SPREAD OF THE INSECT

But few instances of the transportation of the insect have been observed, and these are of such a nature as to account for but a small portion of the infestation. The most fruitful source in the past has doubtless been through the transplanting of trees, for this is done when the insect is firmly attached in the hibernating stage. Over short distances they may be transported on the feet of birds or clinging to the parts of insects. The eggs hatch during summer when there is little migration among birds so that great distances are probably not made in this way. It is not probable that many migrations of this kind are made in the fall when the insect is moving from the leaves to the twigs, since the insects at this time are probably too large to be readily carried by these means. Either the newly hatched young or gravid females may be transferred from tree to tree by the interlocking of limbs or by

first falling to the ground. Prof. Garman found a goldfinch's nest covered on the outside with nests of *Pulvinaria*. Mr. Hubbard believed that spiders were the chief means of transportation.

ENEMIES

As might be expected, the cottony maple scale, being a native insect, is preyed upon by a wide range of enemies which includes both those which prey upon insects in general, and the groups which confine themselves to a smaller range of hosts.

The only instance of a vertebrate being among the group was observed by Dr. Howard, when he saw an English sparrow eating the waxy masses in Washington. That these birds do not offer much hope of relief is evident when we remember that the most serious outbreaks of the pest have occurred in those places where this sparrow is most abundant.

The *Arachnida* have come to the rescue but once and that was when the harvest mites were found by Miss Murtfeldt feeding upon the eggs in Missouri.

The larvæ of a species of lace winged flies (*Chrysopa*) and two species of assassin bugs (*Reduviidæ*) were found by Mr. Putnam to feed upon the scales. In Denver, the nymphs of what Mr. Ashmead has determined as *Corizus hyalinus* were found working among the egg masses.

Probably more important than any of the foregoing are the ever faithful ladybirds. *Chilochorus bivulnerus* during all stages of its life, but especially while young, feeds upon this insect. Several species of *Hyperaspis* notably *H. signata, H. bigeminata* and *H. binotata* do good service, while to these must be added *Rhizobius ventralis.*

The larvæ of a species of small moth, described by Prof. Comstock (*) as *Dakruma* (*Lutilia*) *coccidivora* did very effective service in Washington, D. C. According to Dr. Howard:

"This caterpillar flourished upon the twigs upon which the scales were closely massed together, and ate its way through the mass from one scale to another, spinning a close rather dense web as it progressed. Each caterpillar in this way destroyed very many scale insects. The writer has always thought that it was due to this insect alone that the cottony cushion scale almost disappeared from the Washington shade trees in the close of 1879, and was never seen here again until, in the summer of 1898, nineteen years later, it became once more rather conspicuous, although by no means as abundant as in the former year. The *Dakruma* not only destroys the old wornout female, but devours her eggs and young larvæ with avidity. The caterpillars are very active, moving about freely within their silken passages. They were to be found full grown on June 24, spun their cocoons within the silken tunnel, and remained ten days in the pupal state. The moths issued from July 17 to August 13, soon thereafter ovipositing and laying their eggs, which hatched in six days. Whether another generation of moths issues the same year has not been determined."

Prof. Riley states that in Florida this larvæ attacks "a large *Lecanium* on magnolia, a coccid allied to *Dactylopius* and the common "turtle back scale."

But the credit for the most effective work of eradication of the cottony maple scale is due after all to the chalcid parasites. The general insect enemies are helpful at all times, and in some cases become quite important, the *Dakruma* larvæ have been locally beneficial,

(*) Report Dept. Agr., 1879, 241-243.

but the scale is never able to withstand the onslaught of the chalcid parasites. The most important of these is *Coccophagus lecanii* Fitch This minute parasite was reared by Putnam during his study of the insect and appeared in Washington, D. C., in such numbers in 1898 as to interrupt the experiments of Dr. Howard. It is very widely distributed and has been reared from other scales of the Lecanine group. The adult is a minute, black four-winged fly, marked with a crescent shaped yellow patch in the middle of the body above. Dr. Howard states that less than one per cent of the larvæ which settled upon the leaves under his observation escaped destruction by this parasite. The scales were stung during midsummer. They afterward turned black and the parasites emerged through holes out of their backs. The development of the parasite was very rapid, not occupying more than two or three weeks. Mr. Putnam believed that there were two generations, but Dr. Howard thinks that there may be many more. Closely allied to this species is *C. flavoscutellum* which does for the southern range of the scale the work accomplished in the north by *C. lecanis*. Its range, however, is not confined to the south for it has been reared by the writer from scales taken in Denver.

The other chalcid parasites appear to be of less importance. *Comys fusca* Howard is a common parasite on Lecanine scales and widely distributed. *Aphycus pulvinariæ* Howard was reared by Mr. Putnam, and *Atropates collini* Howard was bred in both 1889 and 1891 by Dr. Howard from females of the cottony maple scale from Brooklyn and Roslyn, N. Y. *Eunotus lividus* Ashmead has been reared in March and April from old scales, the parasites spinning clusters of stout cocoons under the bodies of the old scales. Specimens were reared by the writer from egg masses taken in Denver during July. (See Fig. 4.) In each case, however, there was but one cocoon under each scale. Specimens of *Cheiloneurus albicornis* have been found in our breeding cages.

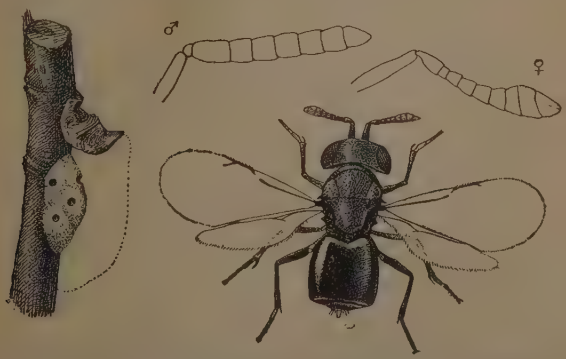


FIG. 4. EUNOTUS LIVIDUS, greatly enlarged, with male and female antennæ above-still more enlarged. (Howard Bul. 22. Div. of Entom., U. S. Dept. Agr.)

REMEDIES

The history of the remedies is very brief owing to the fact that

the insect has not often been a serious pest in any one locality long enough for the problem to be worked out.

Summer Treatment.—In 1884 Dr. Forbes made a number of preliminary laboratory experiments on the effect of insecticides on young lice. A leaf dipped in 2½ per cent kerosene emulsion showed that the lice were killed. A branch treated in the same way showed a mortality of three-fourths in twenty-four hours. A branch sprayed with the same preparation showed one-half dead after four days. A branch dipped in five per cent solution killed all. Whale oil soap appeared to be less satisfactory for the larvæ were not all killed with a solution weaker than one pound to two gallons, and these strengths all did greater or less injury to the foliage.

In the summer of 1904, Mr. H. E. Weed did considerable spraying in the parks of Chicago. The work began in the middle of July and extended to the first of September. Kerosene emulsion of eight or ten per cent strength was used at first, but afterward increased until fifteen per cent was reached. The results I give in his own words:

"Practically none of the insects were killed with either the eight or ten per cent emulsions. An examination at Prof. Forbes' office of leaves sprayed with 12½ per cent some days after showed that something over fifty per cent were killed but the death of some of these was doubtless due to natural causes. The fifteen per cent emulsion killed the greater portion of the *Pulvinaria*, but as this strength took practically all of the leaves off the boxelder, all from the lindens and fully one-half from the maples, the remedy was at least equal to the disease."

The failure of these later treatments compared with those of Dr. Forbes is doubtless due to the age of the young scales. It is probable that the greater portion of the young larvæ were protected by waxy excretions of considerable thickness by the middle of July. From experiments which are described below I am convinced that the newly hatched larvæ are very easily killed. Kerosene emulsion as low as five per cent and Good's whale oil soap as weak as one pound to four gallons appeared to be entirely effective.

From the foregoing it must appear that a summer spray for the young scales alone must be a very protracted and expensive task. It is probable that a weak spray will not be effective on a scale more than a week or ten days old. The greater portion of the eggs hatch probably between the middle of June and the first of August. This would necessitate from four to six very thorough treatments to greatly reduce the numbers, even granting that all of the lice may be reached by each spray, a condition which anyone who has had very much practical experience would hesitate to admit.

In the summer of 1904, the writer made a number of preliminary experiments for the purpose of pointing the way to a summer treatment. Since these have not been published before they are given in full. The first eleven were treated on July 3, and the others on July 5. The examinations were all made on July 14, and eggs which appeared to be alive in Nos. 4, 5, 10, and 16 were isolated and examined July 26.

TABULATED STATEMENT OF TESTS WITH INSECTICIDES

EXP.	CONDITIONS.	INSECTICIDE	RESULTS
1	Large scale full of unhatched eggs. Some larvæ running about.	Ker. Emul. 50% kerosene	Everything soaked with oil and dead.

TABULATED STATEMENT OF TESTS WITH INSECTICIDES (CONTINUED)

EXP.	CONDITIONS	INSECTICIDE	RESULTS
2	Four large scales. Eggs and larvæ.	Ker Emul. 33 1-3% kerosene	Everything soaked with oil and dead
3	Several large females. Eggs and larvæ.	Do. 25%	Everything appears to be dead.
4	Mass of females. Eggs and larvæ.	Do. 20%	Emulsion penetrated well. A few eggs under one scale appeared to be alive, but failed to hatch by VII, 26.
5	Isolated females. Eggs and larvæ.	Do. 15%	Larvæ and most eggs dead. Two scales had fresh eggs under them, some of which had hatched by VII, 26.
6	Isolated large female	Do. 10%	Larvæ reached are dead. Emulsion did not penetrate. Abundance of eggs and larvæ in center of masses.
7	Clustered females. Well protected eggs and larvæ.	Do. 5%	Exposed larvæ and eggs under smaller scales all dead. Large masses with many young.
8	Scattered females.	Tak-a-nap, 1 lb to 1 gal. water.	Penetrated and killed well. Two live lice under one scale.
9	Large masses.	Do., 1 lb to 1½ gal. water	Everything appears to be dead.
10	Masses of females and eggs.	Do., 1 lb to 2 gal water.	Everything dead except possibly one large mass. Eggs did not hatch by VII, 26.
11	Isolated females.	Do. 1 lb to 3 gal. water.	Penetrated well. Everything dead.
13	Isolated scales. Not large.	Good's whale oil soap, 1 lb to 1½ gal. water.	Eggs and larvæ all killed.
14	Many females, larvæ and eggs.	Do. 1 lb. to 2 gal water.	Masses penetrated and everything killed.
15	Do.	Do. 1 lb. to 3 gal water.	Everything exposed, dead. A few live larvæ under two scales.
16	Clustered females.	Do. 1 lb. to 4 gal. water.	Eggs and larvæ killed where reached. Penetration poor. Eggs from center masses hatched by VII, 26.

The preparations were applied in the laboratory by means of an atomizer. An examination of the table shows that eggs and newly hatched larvæ are easily killed even with the weakest strengths used. The point of difficulty is to secure a treatment which will penetrate the cottony masses. The experiments must be considered indicative at best, but they show that kerosene emulsion twenty per cent or more in strength, and the soaps at the rate of one pound to two gallons or stronger, will probably be effective. These insecticides cannot, of course, be used as a spray on the foliage. It will be necessary to apply them by means of a sponge or brush.

To Sum Up.—Summer treatments in practical experience have proved a disappointment, and must be considered a makeshift at best. If they become necessary, it will be better to combine two methods. As soon as the cottony masses appear, or certainly before the eggs have hatched in large numbers, trim out and promptly burn the infested twigs and such limbs as may be removed without seriously marring the appearance of the tree. The remaining masses should then be thoroughly soaked with a strong kerosene emulsion or soap solution not less than one pound to two gallons in strength, the insecticides being applied with a brush or sponge.

Winter Treatment.—During 1903 and 1904 the writer conducted a series of experiments in the parks of Denver under the direction of Prof. Gillette, and with the consent and assistance of the park authorities. Since these were published in detail with the Proceedings of the Association of Economic Entomologists (Bu. of Entom. Bul. 52) they will be but briefly reviewed here.

Preliminary laboratory experiments conducted during January, 1903, in which lime sulfur salt, kerosene emulsion, and hard whale oil soap were used showed little or no benefit from the first substance. Kerosene emulsion killed satisfactorily when twenty-five or more per cent in strength. The next application was twelve and one half per cent in strength and did not seem to be effective. Hard whale oil soap one pound to one gallon worked well, killing all exposed scales. The weaker strengths did not show an appreciable value. These experiments were repeated a week later, with practically the same results, except that the whale oil soap did not furnish such favorable data.

The following winter two series of experiments were conducted in Curtis park, Denver. In the first, kerosene emulsion killed satisfactorily as low as twelve and one half per cent kerosene. Tobacco stem decoctions were entirely inefficient. Bowker's tree soap at two pounds to one gallon shriveled the scales; at one pound to two gallons, killed two-thirds. Much to my regret, the test of one pound to one gallon was overlooked in checking up. This was unfortunate because this insecticide promised to be more useful than any of the soaps previously used.

In the second series, kerosene emulsion again killed as high as ninety-four per cent when only twelve per cent kerosene in strength. Lime sulfur salt was again a total failure. Hard whale oil soap at one pound to one gallon killed ninety-eight per cent of the scales.

As a result of this work kerosene emulsion, one-sixth kerosene, was

recommended and used in the parks of Denver. In July, 1905, I carefully examined Fuller park which had been treated in this way and was surprised to find it clean. Not more than a dozen of the cottony masses were to be found and there were practically no scales on the leaves. A reexamination of the same park in January, 1906, however, showed that almost every tree was infested with a few scattering females, which proved, I think, that the eradication of the scale is a practical impossiblity.

The climate of Denver is much drier than that found in most parts of the insect's range. The last set of experiments, however, were conducted during a wet period, but the results did not appear to be seriously affected. Mr. Braucher writes me that kerosene emulsion has been used in the Chicago parks about twenty per cent in strength with most excellent results.

The winter treatment is the ideal one from a number of considerations. The insects are more easily reached, for the twigs and limbs are exposed. Insecticides may be used in sufficient strength to kill without injury to the tree. The hibernating females are generally on the under sides of the limbs and most abundant on the lower branches, which makes the application more easy. The amount of insecticide required is less than half what it would be in summer.

To Summarize.—The cottony maple scale may be controlled by a winter treatment of kerosene emulsion fifteen per cent or greater in strength, and probably by whale oil soap at the rate of one pound to one gallon. It may be necessary to use a higher percentage of kerosene where the climatic conditions are unfavorable. Eradication of the scale is not to be expected and only such trees and areas should be treated as are threatened with serious injury.

Too great stress cannot be laid on the thoroughness of the work. The tree should be treated from both sides and from beneath each limb. After treatment each tree should be carefully inspected and the missed spots "touched up."

The kerosene emulsion should be carefully made. It is better to use more soap than the ordinary formula, since soaps vary somewhat in emulsifying powers and the satisfaction of a good emulsion more than repays the slight extra cost. During 1906, the Denver park authorities used in part a soft naptha soap. Twigs which had been treated with this emulsion were sent to this office and examination showed all the insects to be dead.

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Bulletin 117 January 1907

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

THE COLORADO POTATO INDUSTRY

BY

E. R. BENNETT

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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THE COLORADO POTATO INDUSTRY.

A Preliminary Report Based on One Season's Study, Partly Aided by State Appropriation of 1905

E. R. BENNETT

THE POTATO INDUSTRY OF COLORADO has a number of peculiarities. The total yield of the state (8,000,000 bu.) as compared with some of the other great potato producing states is not large. In the East the great yield of potatoes comes not from any one area but for the most part from small acreages on each of the many small farms over the whole of a state. In Colorado the potatoes are grown only in certain restricted and well defined districts. On these areas potatoes are the most important product and the other crops are an adjunct to or an element in the system in the preparation of the land for this crop. It is not an uncommon thing in these districts to see fields of from forty to one hundred acres of potatoes on farms of a quarter section.

The problems confronting the growers in this State, as to cultural methods, insect pests and fungous diseases, are also radically different from those of the Eastern States. Many of the fertile irrigated tracts do not produce potatoes successfully, though they are near and similar in most respects to the so called potato districts. Why this is so has not so far been satisfactorily explained. The writer has spent the past summer in studying the conditions and methods under which the potato is grown in some of the more successful districts and comparing the methods employed at different places. Of the potato producing sections of the State, the irrigated land surrounding Greeley known as the Greeley District, the water shed between the Arkansas and the Platte Rivers known as the Arkansas Divide, a small section of the San Luis Valley, the Valley of the Roaring Fork of which Carbondale is the center and the Uncompahgre Valley are the most important. A few other small mountain valleys produce a limited quantity for the local mining trade.

The Greeley District exceeds all the others as to area and amount of potatoes produced. It is about twenty miles long from northwest to southeast and twelve or fifteen miles wide at its greatest width. It includes about 200,000 acres of land, though probably not more than one-eighth of this tract is ever put in potatoes at any one time. The total yield per year of this tract is from 9,000 to 14,000 cars or 4,000,000 to 6,000,000 bushels.

Comparatively few varieties of potatoes are grown in Colorado. Nearly all the known varieties have been tried at one time

or another and only a few have proved profitable. The districts differ somewhat in the varieties grown owing partly to the market demands and partly to the difference in soils, elevation and length of seasons of the different places.

THE POTATO INDUSTRY

THE GREELEY DISTRICT. Potatoes have been grown in this district since the foundation of the Union Colony in 1870. At first the bottoms of the Big Thompson produced the most, then the "blight," probably Rhizoctonia, became so bad there that practically none have been grown for several years. After the Big Thompson bottoms began to fail as a potato producing section, they were grown in and near the town to the south of Greeley. Then the blight became so bad that few could be raised in and around town which is mostly on the Laurel* sand loam of the river bottom. As the country north and east of town became broken up, the industry was given a new impetus. As the cultivated area grew the production of potatoes increased but was limited both as to area of land devoted to potato growing, and yield, till alfalfa was brought in as a part of the regular rotation about 1886. Previous to that time alfalfa had been grown to some extent but it was not thought possible to break it up successfully. From 1886 on, the yield of potatoes increased and potato growing as an industry became one of the leading occupations of the farmers north and east of the town. Mr. Boyd in his "History of Greeley" written in 1890 says: "the shipments for the past five years from the Greeley District have been from 1,000 to 1,800 cars a year." Now the shipments are from 8,000 to 14,000 cars.

The blight (Rhizoctonia) has given trouble more or less from the beginning. The Colorado potato beetle has caused some loss at times. Mr. Boyd says in his history of Greeley: "In 1889, fourteen thousand pounds of Paris Green were sold at Greeley and Eaton for spraying potato vines for the striped potato beetle." Locusts have occasionally caused some damage. On the whole, adverse conditions have been fewer than in most potato growing sections of the United States and the growth of the industry has been normal and constant.

The history of the other potato districts of Colorado is similar to that of Greeley.

THE CARBONDALE DISTRICT. Potatoes have been grown in the Carbondale District to some extent since its early settlement. Growing potatoes as a commercial industry, however, did not begin till within the last eight or ten years. At present the production

*U. S. Department of Agriculture, Bureau of Soils, 1904.

is limited only by the amount of irrigated land on the mesas and in the valleys of the Roaring Fork and Crystal Rivers. The soil and climate of these valleys are admirably adapted to the growth of potatoes. Owing to the high elevation and the proximity of high mountains, this district has a shorter growing season than the Greeley District and potatoes are planted correspondingly earlier. The soil is for the most part a red or blackish sandy loam on the mesas with a somewhat gravely soil in the river bottoms.

The methods of culture are similar to those practiced in the Greeley District. Alfalfa is rotated with grain and potatoes. One difference in practice is that seed is planted closer. The hills there are nine to twelve inches apart instead of thirteen to fifteen inches. The rows are also a little closer together being from thirty to thirty-six inches apart instead of thirty-eight or forty.

Few places can compete with the Carbondale District either in yield per acre or in quality of the product. The yields per acre vary on the different ranches according to the natural conditions of the soil and the fertilizers and methods of cultivation used but a high average yield is maintained.

Here as at Greeley nearly all the potatoes raised are of the late varieties. Early potatoes do not yield sufficiently well to pay, nor come early enough in the season to bring the maximum price of early potatoes. The most popular variety is the Improved Peachblow, sometimes known as the Red or White McClure. Other varieties are the Pearl, White Beauty, Carmon No. 1 and Challenge. The output for the valley is from 300 to 500 cars, or from 150,000 to 250,000 bushels.

Quite a large per cent of the West Slope potatoes find their way to special markets for hotels and dining car service. The remainder supply the mountain towns or are sent into the same markets as the other Colorado potatoes.

THE SAN LUIS VALLEY DISTRICT. The culture of potatoes in the San Luis Valley is somewhat different from that of the other potato districts of the State. The crop has been grown there since the early settlement of the State. Before the railroad was put through the valley, potatoes were freighted by wagon to Leadville and other mining towns.

Alfalfa is not grown to any extent in the valley but peas take its place in the rotation.

The soil varies in different locations but that on which potatoes are grown is a dark sandy loam underlaid with gravel. Sub-irrigation is practiced here. The gravel contains water at only a short distance from the surface so by running water in shallow ditches twenty or thirty feet apart, the water table is raised so that the moisture is brought to the surface.

The varieties grown are the Monroe County Prize, Rural N. Y. No. 2, Pearl and Champion. The yield is at present about 400 cars. Most of these potatoes are marketed in New Mexico or Texas.

The tendency toward running out is not so noticeable here or at Carbondale as in the Greeley District. In fact the same seed has been kept at both these places for at least fifteen years without deteriorating.

THE DIVIDE DISTRICT. The Arkansas Divide is the only place in the State of any extent where potatoes are grown without irrigation. Conditions cannot so well be controlled and the yield is correspondingly less. A specialty is made of growing potatoes for seed in this locality. As much of this seed is used in the Greeley District the same varieties are grown.

The culture given the crop is similar to the other places except that more surface cultivation is necessary to conserve the limited amount of water though the rainfall is considerably in excess of other parts of the State.

METHODS OF POTATO CULTURE IN THE GREELEY DISTRICT

Owing to the character of western soils, system of irrigation, large acreage of potatoes per farm and rotation of crops, the methods of potato culture in Colorado differ somewhat from those of other sections of the country. At first the methods of irrigation and cultivation best suited to the conditions here were not well understood but since it was found that alfalfa could be successfully broken up and that deep cultivation was most beneficial the methods have not changed to any considerable extent.

There is a prevailing opinion that potatoes require a certain kind of soil. There undoubtedly is a relation between the yield and quality of potatoes at certain places and the different soils. Just what this relation is, however, has not as yet been successfully explained. Good yields of potatoes are produced on several different soils and failures occur on all of them.

SOILS. The soils used for potatoes in the Greeley Potato District are: *Billings loam, Colorado fine sand, Colorado sand, Billings clay loam and to a certain extent Laurel sand loam.

The Billings loam is a heavy soil well mixed with sharp granitic gravel. It has a depth of from two to five or six feet. This soil is underlaid with gravel which gives good under drainage. More care has to be exercised in handling this soil because if worked when too wet or too dry, it is more liable to become lumpy than are the lighter loams.

The Colorado fine sand loam is intermediate between the Billings loam and the Colorado sand. It is generally deeper than

*U. S. Department of Agriculture, Bureau of Soils, 1904.

the Billings loam and does not pack or become lumpy so easily as the latter but on the other hand it contains less gravel. These two soils constitute by far the larger part of the successful potato district north and east of the town of Greeley.

The Billings clay loam is finer than either of the others. It has less gravel and is so deep that the under drainage is not good. This soil occupies narrow strips in the creek bottoms and while it often produces good crops of potatoes it is liable to serious attacts of fungous diseases.

The Colorado sand is coarser in texture, contains less nitrogenous matter and requires more water to produce a crop but where proper rotation of crops and cultural methods have been employed, good results are obtained.

The Laurel sand loam, which is the first bottom land of the Poudre River Valley, is not very different from the other sandy loams but in most places the water table is close to the surface and potato growing on this soil in not uniformly successful.

All these soils contain more or less alkali but not enough in most cases to prevent the development of plants except where water stands and evaporates.

PREPARATION OF POTATO LAND. The preparation of the land for potato growing is probably the most important item of the work. The difference between new land broken for potatoes, old land and alfalfa land is most marked. The new land produces a very clean grade of potatoes but does not give so good a yield as land either preceeded by potatoes or alfalfa. Alfalfa land gives the largest yields and is less liable to disease than where potatoes succeed potatoes. The universal practice is to rotate so as to preceed potatoes with alfalfa.

ROTATION OF CROPS. The most common rotation is alfalfa two or three years, potatoes two years or where beets are grown, potatoes one year, and beets one year, then grain two years. Sometimes wheat or oats are only grown one year but experience has shown that in the majority of cases, the first year of grain following potatoes or beets produces so much straw that the young alfalfa is smothered out if grown. The grain, owing to the reduced fertility of the soil, is not so large the second year and makes a better nurse crop for the alfalfa. Another rotation practiced to some extent is alfalfa two years, potatoes one year, wheat one year, potatoes one year, grain, then alfalfa again. This system while not very generally practiced has some possibilities in the way of "blight" control which will be spoken of later in this report. The number of years alfalfa should be allowed to grow to get the land in the best condition for potatoes is an open question.

While by far the majority of growers allow it to stand but

two years, it is the opinion of some authorities and many of the best practical farmers that it would do most good if left three years. Some think that even six or seven years would be better.

Winter sheep feeding has changed the rotation to some extent. When enough sheep are fed to produce a good coat of manure for the potato fields, potatoes are followed with potatoes twice or potatoes once and once with beets. Very substantial gains in yield of both potatoes and beets have resulted where manure has been used. The use of manure on land here as well as in the Eastern states is cumulative in its effects and benefits particularly the heavy soils in two ways. The physical condition of the soil is improved by being made more porous and friable so that it will hold moisture better and of course, plant food is also added to it.

PLOWING. In the preparation of the land for potato growing the plowing is not the least important. This is sometimes done in the late fall but more commonly in the spring from the latter part of April to May 15th. Fall plowing gives good results but ordinarily time for doing the work cannot be found at that season or the land may be too dry to make plowing possible. The depth of plowing ranges all the way from six to twelve inches but nearly as many plow eight inches deep as all other depths taken together. The work is generally done with four horses and a 14-16" plow. When alfalfa is being broken the plows used have a wide share so that all the alfalfa roots are cut off at the bottom of the furrow.

A practice that is to be commended in other places as well as on the irrigated land of Colorado is that of following the plow immediately with the smoothing harrow. This is done partly to mellow the soil and prevent the formation of lumps but mostly to conserve the moisture. Experiments have demonstrated that the loss of moisture by evaporation is much less where this is done than where the plowed land remains for a time without harrowing. In this State the practice is to harrow all the land that is plowed each half-day before leaving the field.

HARROWING AND LEVELING. In many fields scrapers are used after the first harrowing to fill the hollows and take down any ridges that are liable to cause trouble in getting water evenly distributed over the field. The amount of work required to fit the land for planting after the first harrowing and leveling depends on the character of the land. With average loamy soils one or two subsequent harrowings are sufficient to put the soil in perfect condition for planting. If the soil is heavy or has been packed by rains, the disk harrow is used and followed by the smoothing harrow.

PLATE I. CULTURAL OPERATIONS.

1. Furrowing. 2. Digging. 3. Cultivating. 4. Planting.

PLATE II. Conveniences for Cutting Seed Potatoes. Notice the Knife in the Board.

PLATE III. Irrigating Potatoes—alternate rows.

PLATE IV. POTATO CELLARS.

PLANTING. Much diversity of opinion prevails among the growers as to the details of preparing seed and planting. The general practice is to select seed from the stock which is left over winter in the storage cellar for the spring market if home grown seed is used. If not, the seed is purchased from the Divide country, the mountains or from the East. Medium to small seed is used by the majority of growers. Some make a practice of "greening" the seed. That is the seed is spread in a thin layer on the floor of the dugout a few weeks before planting time. The ventilators and doors are left open to admit the light. Occasionally the potatoes are shoveled over to give a uniform exposure so that by planting time the tubers have become hardened and green, and the sprouts, if there are any are short and green instead of being long, slim and pale. The formailin or corrosive sublimate treatment is seldom used. Cutting is done by hand. The number of eyes depends on the variety as some varieties of potatoes have many eyes while others have few. The usual aim is to leave two eyes on a piece, but the rule is not arbitrary. In fact the work coming at the busy season makes it necessary to employ inefficient help so that some pieces are left with many eyes while others have none. A method of cutting shown in Figure 2, Plate I, is thought to facilitate the work to some extent. The potatoes are shovelled into a bin or hopper made of a dry goods box raised on legs. The back is made higher than the front so that the potatoes will run down to the opening. In the bottom are cracks to let out the soil that is shoveled up with the potatoes. The cutting is simple. An old case knife or a shoe knife is fastened to the end of a piece of plank or board in such a way that the potato can be pushed against the knife and fall from it into the basket beneath. The seed is planted soon after cutting as it is thought that the vitality of the buds rapidly becomes lowered as the seed drys out.

Various substances are used on the cut seed that are supposed to be beneficial by drying the cut surfaces and preventing the work of insects or fungi. Air slaked lime, flowers of sulphur and gypsum (land plaster) are all used by different growers. All these are used in the same way. The cut seed is piled on a floor, the material is scattered on and then mixed by shoveling the pile over till the dust is brought in contact with each piece.

VARITIES. Very few early potatoes are grown. Early varieties have frequently been tried but the yield is seldom satisfactory and the crop cannot be marketed in time to get a high enough price to make up for the deficiency in yield. Mammoth White Pearl leads all the other varities in acreage and generally in yield. Rural N. Y. No. 2 is second in popularity and some

Ohios and Snowflakes are planted. Nearly all the known varieties have been tried in this district at one time or another but none of them have been able to compete with those named. The long potatoes tend to become longer and roughened and in a year or two degenerate or revert to what is supposed to be the ancester of our present race of potatoes. Owing to this tendency for seed to "run out" the same stock is not used more than two or three years.

PLANTING. All planting is done by machinery. Among the different makes of planters used are the Aspinwall, the Evans, the Superior, the Robins and the Excelsior. All these planters require cut seed. Very little difference can be seen in the work of any of them. Four horses are used with these planters and five to seven acres planted is considered a days work. The rows are from thirty-six to forty inches apart, with a distance between plants in the row of thirteen or fifteen inches.

CULTIVATION. Very soon after planting the first cultivation is given. The ridge left by the planter shows the rows so the plants do not need to be seen. The object of the first cultivation is two-fold. First the tramping of the four horses used on the planter packs the ground solidly. This needs to be loosened to aereate the soil and prevent loss of moisture by evaporation. Second the alfalfa or weeds that are starting are killed. For this work, four horses on a heavy four shovel John Deere type of cultivator are used. The shovels are set to run as deep in the soil as they will go which is from eight to twelve or thirteen inches. They are also set so as to throw the soil toward the potato rows, thus beginning the hilling or ridging process which is characteristic of potato culture in this locality. This operation leaves the soil loose but more or less lumpy, and with a rough uneven surface, especially on the heavy soils. The harrow immediately follows the cultivator to re-establish the soil mulch. These two operations destroy the young weeds so there is little trouble in keeping the field clean.

The number of cultivations depends upon the weather conditions and rapidity of growth of the vines. The cultivator is used a second time as soon as the plants are large enough so that the rows can be easily followed. This time the shovels are not run quite so close to the row but to the same depth unless the plants are much developed. In that case the inside shovels are raised so as not to injure the root system. Sometimes two cultivations are all that are given but ordinarily a third follows the second by a week or ten days and if the vines do not get too large or irrigation become necessary, cultivation is continued. Each time the cultivator is used more soil is thrown toward the potato rows

and the hollow between the rows becomes deeper, thus ditching is more easily done.

Ditching and irrigating are delayed as long as possible. The rule is not to irrigate if it can be avoided till the potatoes are in bloom or the tubers set.

DITCHING. The ditching is done with a narrow double mold board plow. Three horses are attached and the plow is run once in each row at about the depth of cultivation or ten to twelve inches. This ditching takes the place of one cultivation and if the ground is hard or if the first irrigation fills the ditches to any extent, the operation is repeated so as to make the ditches deep enough to keep the water below the surface of the potato ridges.

IRRIGATION. The details of irrigation depend upon the size and contour of the field to be irrigated. Many of the fields are arranged so that the rows are from one-fourth to one-half mile long. If the land slopes sufficiently and continuously across the field from the supply ditch, the problem is simple. At the first application the water is turned into a lateral at the head of the rows. A canvas dam is placed in the lateral so as to hold the water back and raise it into the rows. After the water has run in these rows a sufficient length of time to thoroughly wet the soil, the canvas dam is pulled out and reset farther down the lateral, and the water is stopped by blocking the heads of the irrigated rows with soil. In large fields the water is run in alternate rows only.

The head of water let into the rows depends upon the slope and length of rows. If the rows are short and the incline steep, the head must be small or the stream will reach the far side so quickly that enough water will not be used to thoroughly wet the soil. On the other hand, if the rows are long and the land nearly level the head of water is increased so as to force it along the rows faster, or a transverse ditch is cut through the middle of the field so as to shorten the distance that the water has to flow. If ridges occur in the field transverse ditches are run along at their top and irrigating is done both ways from it. When the water has run in the ditches till it seeps through to the unirrigated row, the soil is sufficiently wet. At the second irrigation the water is run in the rows not irrigated the first time. As the vines become large, the irrigation becomes more difficult owing to the lodging of the vines in the ditches, till at last considerable trouble is sometimes experienced to get the water through. On the other hand as the vines grow larger the soil is more protected from the sun so that the evaporation becomes less and the plants suffer less from want of water.

AMOUNT OF WATER USED TO GROW POTATOES. The number of applications and amount of water used per acre varies with the kind of soil and amount of rain fall. With average seasons the rain fall for May, June and early July is sufficient to bring up the plants and grow them till the tubers begin to form. Irrigation once begun must be continued at intervals of one week to ten days till the crop is developed. Four or five irrigations unless the season be a dry one will carry the crop through. A wide range of opinion prevails as to the amount of water that is best to use in irrigating potatoes. Most of the successful growers hold that in general too much rather than too little water is used. Some measurements taken on the E. R. Bliss ranch show the amount of water actually used in growing a crop of potatoes both on alfalfa land and on old potato land. The applications on a potato field which was preceeded by alfalfa were made as follows: July 25-26th the water ran 17 hours with a delivery of 4.05 feet per second. August 1 and 2, 27 hours with 1.96 feet per second. August 8 and 9, 24 hours at 2.31 feet per second and August 15 and 16, 30 hours at 2.37 feet per second. In all 893,916 cubic feet of water was used. This field was 1218 feet one way by 639 feet the other. This gives an area of 779,520 square feet or 17.88 acres, and a depth of water used in irrigation of 13.76 inches. The rain fall by months from April till October was: April, 3.04 inches; May, 1.73; June, 1.10; July, 2.24; August, .64 and September, 2.31, or 11.05 inches. The September rain was mostly in the latter part of the month and probably did little if any good to the potato crop. If the September rainfall is left out, the precipitation that should be counted as contributing to the growth of the crop will be 8.75 inches. The rainfall plus the irrigation gives us 22.51 inches as the total water used on the crop. This field had previously been in alfalfa for three years. It is Billings loam soil (clay loam) with quite a large per cent of sharp granitic gravel. The soil is about two and one-half feet deep, underlaid with gravel, so it has good drainage. The field was plowed in early May, eight inches deep, harrowed immediately and planted to Pearl and Snowflake potatoes June 1st. The yield of Pearls on this field was above 150 sacks per acre which is near the maximum for the season.

The field adjacent to this one which had grown potatoes the year before gave somewhat different results as to amount of water required, yield of potatoes and time of ripening.

The applications on this field were just previous to those on the alfalfa land potato field. The first run was 14 hours at a discharge of 4.05 feet per second and the second 18 hours at 1.96 feet per second, the third 16 hours at 2.31 feet per second

and the fourth 24 hours at 2.37 feet per second or a total of 668,232 cubic feet of water. This field was 1,300 feet long by 660 feet wide which gives an area of 858,000 square feet or 19.74 acres, and a depth of water over the field of 9.35 inches. The difference in the irrigating water between the old potato land and the alfalfa land was 4.41 inches. This field was planted just previously to the alfalfa field and the potatoes ripened (or the vines died from Rhizoctonia) about two weeks earlier. The yield was about 130 sacks per acre as against something over 150 sacks for the alfalfa land. Frequently a greater difference than this results between alfalfa land for potatoes and land preceeded by other crops. It would hardly seem that the difference comes from the amount of plant food in the soil for after potatoes have been grown on soil even three years, the cereals grown on it will produce heavy crops.

The difference in the amount of water can be attributed to the physical condition of the soil in the two fields. The decaying alfalfa stems and roots make the land more porous and the first irrigation particularly takes more water to fill the soil.

HARVESTING THE CROP. The potato harvesting is done so far as possible with machinery. The diggers used are the Peter Brown and the Doudon type of machines. With these the potatoes are plowed out and elevated over carriers that separate the tubers from the soil and leaves them scattered on the ground. Four or six horses are used on these machines. One machine will keep from ten to fifteen men busy, depending on the yield, picking, sacking and hauling from the field. While these machines are not perfect, they leave the potatoes well separated from the soil, providing the soil is not too wet nor the vines and weeds to numerous. Sometimes a harrow is run over the field before digging to knock down and tear out some of the vines that would clog the digger. When several rows are dug (depending on the number of pickers) the picking and sacking begins. The potatoes are picked in baskets and dumped onto the sorter. This machine is simply a frame on runners to which a horse may be attached to keep it alongside the pickers. On this frame, two seives, made of heavy wire, are placed, slanting to the back so that the large potatoes that will not go through the upper seive roll down into a sack. The smaller ones go through onto the lower seive which is a finer mesh and roll into another sack while the very small potatoes and soil fall through the second seive to the ground.

If the potatoes are to go direct to the market, the sacks are filled and set off on the ground. A man follows the sorter and with a needle and coarse twine closes the sacks by sewing up the top. The filled sacks are then loaded onto wagons and hauled

to the markets. These sacks are made of coarse burlap and hold from 110 to 120 pounds of potatoes. All potatoes are marketed in this way. Much expense in handling and loss from storing is avoided by this system of marketing direct from the field but on the other hand, the markets are often over supplied and the price reduced, by throwing such a large quantity of potatoes onto the market at one time. With the present conditions, however, the marketing of a large per cent of the crop from the field is necessary owing to lack of storage capacity on the farm. If the potatoes are to be stored in the "dugouts" or potato cellars, the sacks are only partly filled in the field then taken to the "dugout" and emptied into bins.

THE STORAGE HOUSE. The dugout or storage cellar is distinctly a dry climate or western feature. While its principles of construction would not adapt it to places of heavy rainfall, it is not only cheap but most efficient as a storage place for potatoes and other root crops in this climate. Being surrounded by soil on all sides, a nearly constant temperature is easily maintained. The loss from shrinkage by evaporation is also less than in ordinary cellars.

The construction of the dugout is simple. An excavation is made in the ground of the required dimensions for the cellar and of a sufficient depth to give soil for covering the top. A frame of posts, timbers and rafters is then made as for a building. This frame is covered with wire netting or brush. Over this two or three feet of straw is placed and this covered with soil to a depth of six to twelve inches. Figure 1, Plate IV, shows the method of covering the cellar with soil. Ventilator shafts are put in at regular intervals to give air circulation and keep the temperature from rising too high. Most of these dugouts have an alley through the center with doors at either end so that the wagon may be driven through. Double doors with a dead air space between are used as a protection against frost.

These dugouts are often filled to their full capacity in the fall to hold the crop for a rise in price. If they are stored while the weather is yet warm the ventilators and doors are left open nights to give a circulation of cold air and closed during the heat of the day. In this way the bins are gradually cooled down and by giving close attention to the temperature the whole mass is kept as cool as possible without danger from frost. During the winter considerable care has to be exercised to prevent the temperature of the dugout from rising from the heat developed by the stored potatoes. This is regulated by opening and closing the ventilator shafts as the case demands.

MARKETS

The position which Colorado occupies in respect to markets is one of the most important factors in making the industry profitable. Her geographical position is such that advantage can be taken of a shortage of crop either east or west of the mountains. And at the same time she is far enough away from the potato producing central states to avoid, to a great extent, the glutted markets that frequently occur when large crops prevail in the Mississippi valley and in the Lake Region. The cities of the east slope of the Rockies with Texas and New Mexico ordinarily get the large share of the crop but not infrequently the Pacific Coast, Central States and even New York and Boston are markets for the Greeley product. Practically all Colorado potatoes are put on the market in sacks. This system is somewhat more expensive than shipping loose in the cars as sacks cost from $6.50 to $8.00 per hundred. The system of sacking, however, has an advantage in that less time is required in handling the crop and the system is growing in favor in all the potato growing sections.

POTATO PESTS

The insect enemies and diseases of potatoes of Colorado are so different from those of the eastern states that the work done there on this subject is of little value to the Colorado potato grower.

INSECTS. The striped or Colorado potato beetle is a native of this state, yet the damage done by this beetle is now ordinarily so slight that no attention is given it by the growers. The flea beetle is, however, a serious pest. Comparatively little is known of the life history of this insect. There are several species similar in general appearance that do more or less damage. The worst one is the black flea beetle (Epitrix cucumeris). The last of May or the first of June these little flea-like beetles may be seen in quantities feeding on the weeds along the fences and ditch banks. They are black or dark brown, shiny and about one-tenth of an inch long. When disturbed, the insect jumps and disappears, a trick that gives it the name of "flea beetle." How they pass the winter is not known. Their presence is most noticeable by the appearance of the foliage that has been eaten, as the numerous little holes or light spots on the leaves of potatoes as well as tomatoes and the cucurbits are due to them. These perforations in the foliage injure the plant by rducing the leaf surface and also by giving entrance into the leaf of various plant diseases. Just how much the yield of tubers is cut down by this injury to the foliage is difficult to estimate. Later in the season the insect deposits eggs on the underground stems of the plants. The lar-

vae soon appear as very small white worm-like bodies on the potatoes or underground stems. These larvae are slender and from an eighth to one-fourth of an inch long. If tubers are carefully taken from the soil early in the season where these insects are prevalent, the larvae may be found burrowing into the tuber about one-third of the body being inside. At a casual glance they appear not unlike short root hairs growing from the surface. The injury caused by this insect produces the pimply effect so often seen in potatoes on the market and is often confused with or may be classed as one of the forms of scab. No practical remedy is known for this insect in this state. Spraying with Bordeaux mixture and arsenites destroyes or repells them but the expense of application of this remedy prohibits its use under the system of growing used here. When potato planting is delayed till June first, the injury to the foliage is avoided to some extent for by the time the plants are up the insects have sought other feeding grounds.

This insect is quite generally distributed over the country but is more prevalent in some places than in others and is also more numerous some seasons than others. The past season they have been particularly numerous, probably owing to the preceeding mild winter.

Not infrequently scabby or injured potatoes are infested with numerous small white worms so that there is quite a general opinion that the scabbiness or injury is caused by them. This is not usually the case. The injury or scab is caused by some other agent and the worms, which are saprophitic, work in the dead tissue and by so doing are credited with the damage. When earth worms are particularly plentiful the potatoes may be made dirty as a result of the worms crawling over them and leaving a slime to which the soil sticks.

FUNGOUS DISEASES. The fungous diseases of Colorado potatoes differ widely from those which cause the serious losses of the East. Early blight (alternaria) can be found but so far as is known little or no damage has resulted from it. The late blight (Phytophthora infestans) has never appeared at all.

CORTICIUM VAGUM B. & C. (*Rhizoctonia*). The serious fungous pests of Colorado are mostly those that work below ground. Bulletins Numbers 70 and 91 by F. M. Rolfs describe the one fungous disease that causes most of the loss to potato growers of this state. This disease evidently is not new to this locality for Boyd in his History of Greeley in speaking of the potato industry during the Seventies says: "For the first two years potatoes did well near Greeley on this side of the river. For some twelve years none could be raised in and around town. They did, as a rule,

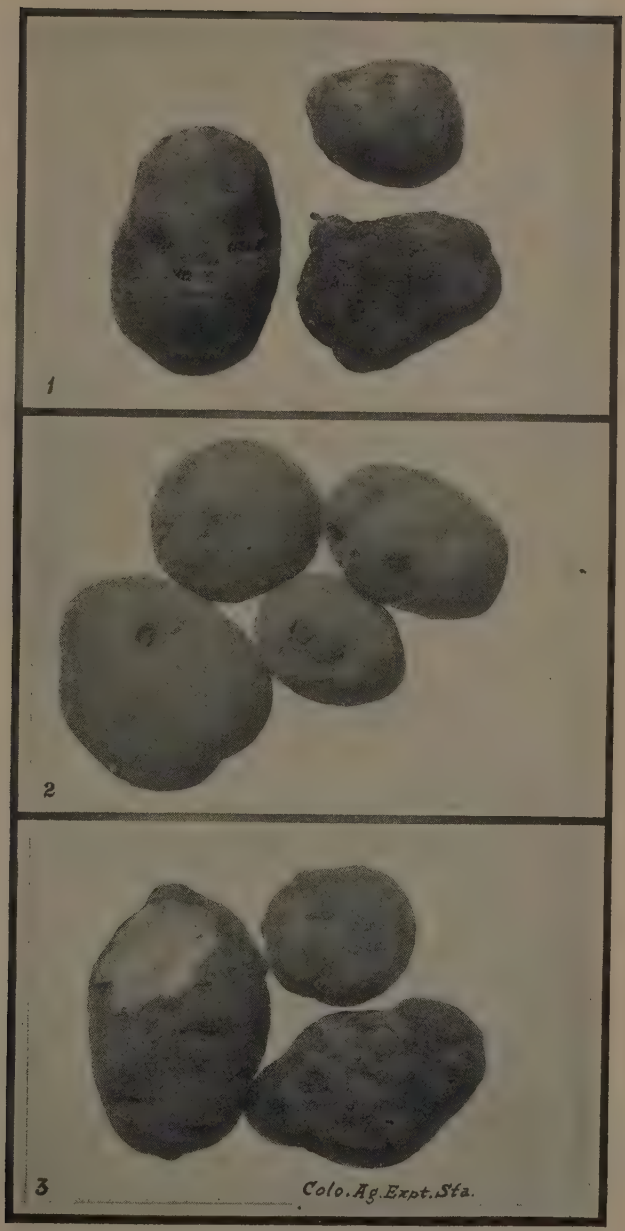

PLATE V. SCAB OF POTATOES.

1. Surface Scab. 2. Deep Scab. 3. Apparent Scab—work of the Beetle.

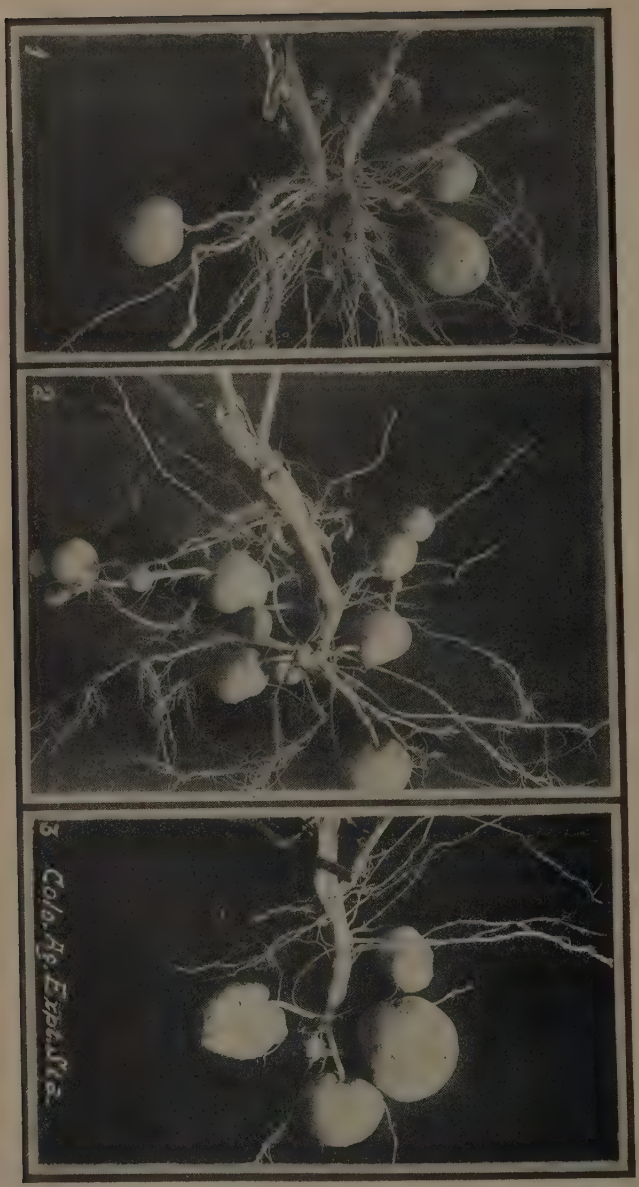

PLATE VI. HABITS OF GROWTH.

1. Rural N. Y., No. 2. 2. Improved Peachblow. 3. White Pearl.

no better on newly broken sod than on old sand. Heavy manuring of the land did not help the matter. The vines were struck with a rust or blight. This fungus made the leaves thick and stiff, and undoubtedly destroyed the sap and prevented the leaves from carrying on their function."

This is a good superficial description of the effects of this fungus as it looks in the field. From its past history it is evident that meteorological conditions have a strong influence on the behavior of this fungus. Probably there has been no year since the growing of potatoes began in this State that the disease has not been present, but much of the time, at least in the more favored locations, its attacks have been so light that it did not attract the attention of the growers. A high temperature, excessive moisture, alkali and a compact soil are all conditions that probably favor the development of the fungus. It has been generally supposed that this disease is introduced into the fields with the seed potatoes as nearly all seed tubers have more or less of the fungus on their surfaces in the form of scab or the black dirt-like patches of the sclerotia stage of the disease. Experiments with treating the seed with formalin and corrosive sublimate show, however, that the disease occurs just the same whether the seed is infected with the disease or clean. This fungus is not confined to the potato plant alone. In fact it is not known just how many plants act as a host for it. Peas, beans, beets, alfalfa and many weeds are known to be subject to its attacks. The curious fact remains that though the fungus works on alfalfa, potatoes following alfalfa are not generally as badly diseased and produce a larger crop than when they succeed themselves.

GENERAL APPEARANCE AND EFFECTS OF THE FUNGOUS ON POTATOES. To the ordinary observer, this disease does not become noticeable till the middle or latter part of the growing season. If the plants be examined carefully at any time from the first sprouting of the seed till the harvest, some of them will be found affected with the fungous. Plate II of Bulletin No. 92 of this Station shows the appearance of the disease in the first stages. Not infrequently if missing hills are examined at the time the plants are breaking through the ground the sprouts will be found to have started, but the stems have been girdled with a brown or black canker that stops growth. But if the injury is not serious enough to kill the plant at this stage, it will have a sickly yellow appearance and die soon after getting through the ground. From the time the plants first come up, all through the season, here and there through the field, will be found what the growers call "blighted plants." The leaves are thickened, and with the White Pearl especially, the leaves draw up close to the

stem so as to show the under side and give the ends of the vines a rosette appearance. Microscopical examination of the foliage or upper stems of these plants shows no traces of disease. If the plant be pulled from the ground, the stem will frequently be found scabby, black, or rusty with the center of the stem discolored. If the attack is unusually severe or in the last stages, the whole stem may be entirely decayed below the surface of the ground. In other cases the bark of the stem may seem fairly smooth and clean, but a split stem will show a discolored center. In this case the disease has started at the base of the stem, that is, at the junction of the stem and the old seed. Sometimes healthy looking vines will have rusty canker spots on the stems and no apparent injury result. It appears to be only those vines that are either entirely girdled or those diseased on the inside that are destroyed. The fatal effect on the plant of this disease comes from the hyphae of *Rhizoctonia* crowding into the cells of the stem and stopping the circulation by clogging. In cases where the disease works only on the outside of the stem, large vines with no potatoes are frequently produced or sometimes little potatoes are formed at the axils of the leaves all along the stems. The past season has been unusually favorable for the development of the disease. The loss from it in this state was probably no less than two and a half or three million bushels. The writer found here and there diseased plants in all fields visited during the early part of the growing season. Diseased plants gradually became more numerous, as the season advanced, but were not numerous enough to be considered a menace till the latter part of July, and the first of August, when a large part of many fields showed the disease. By the last of August growth had stopped in nearly all the fields and hardly a plant could be found that was not more or less diseased. Great variation in yield resulted. Fields of Pearls that developed early, yielded one hundred and fifty or more sacks per acre while other near by fields, particularly Rurals, did not exceed thirty sacks per acre. The question of yield this year seemed to be simply a matter of how far the tubers were developd when the growth was stopped by the fungus.

Experiments in the laboratory have proven, that at least a large part of the so called scab of potatoes in this state is a direct result of the action of this fungus. Sometimes it attacks the tubers causing a greater or less degree of scab without causing an apparent injury to the vines. Again both the vines and tubers are affected and frequently the vines are destroyed and no scab will appear. Some localities are so subject to the disease that potatoes can seldom be produced at all.

Why the fungus develops these peculiarities, what condition

make it more prevalent in some localities than in others, and what remedies or methods of culture will prevent the loss from this disease are problems that are yet to be solved.

TREATMENT. Some experiments were made with treatment of soils with copper sulfate at the rate of thirty-five pounds to the acre to test its value as a preventative of the trouble. No effect either way could be detected. Cultural methods employed by different growers have also been carefully noted but with no definite results, other than that all the fields that produced satisfactory yields were given deep cultivation, while the small plots, as those planted in gardens even in the most successful potato growing districts, that were cultivated with one horse or kept clean with a hoe, produced nothing. Many fields that received deep cultivation were also failures.

SUGGESTIONS TO THE GROWERS

Although the potato industry of Colorado is new and only partly developed, the reputation of the product for high and uniform quality is known in all the markets of the country. Few places have the natural advantages for producing the high grade product that the irrigated potato sections of Colorado possess. Because of the high altitude the season is comparatively short without extremes of heat. The nights are cool. The amount of moisture can for the most part be controlled and the soils are deep and rich. All these conditions give the grower an opportunity to produce in the potato the same standard of excellence that is maintained by the fruit growers of the West.

We are not prepared to recommend many changes in the methods of culture practiced in the potato growing sections of this State, as those already in use are the results of a number of years experience in the application of scientific principles of soil management to a system of farming that is hardly known in the East. Undoubtedly the greatest need among the potato growers is organization. This is particularly true of the Greeley District. The compactness of the district, value of the property and large output of the crop, are factors that might make a growers organization there, a success, where in a more scattered or less wealthy community, good results would be less easily obtained. It is not our purpose in this report to suggest or recommend any scheme of organization. The advantages to be gained are many. At present there is no uniform system of grading. Scabby or misshapen potatoes may be put on the markets with the best grades. There is nothing to hinder potatoes from any place being sold as Greeley potatoes. With a registered trade mark and a uniform system of grading this could be prevented and the association

label on each sack would be a guarantee of quality, as is that of the various fruit growers associations in the West. Comparatively few consumers have any knowledge of varieties in potatoes. The people who buy Greeley potatoes and get a certain color and quality expect to get the same thing at the next purchase. If many varieties are grown and all go under one name disappointment is sure to follow and the reputation of the product is injured. Only a few varieties are now grown. One or two of these do better than any of the others so there is little reason for growing any but these standard varieties for the general market.

SEED TREAMENT

Results from the use of formalin or corrosive sublimate treatments have not been such that we can recommend their use. Both substances have caused more or less trouble from retarding the germination of the seed and in some cases the seed has been killed by their use. In these cases it is probable that the material was used too strong or the seed was left in the solution too long. Granting that the use of these materials will clean the seed of infection of the scab, the treatment is practically worthless so long as the soils are contaminated with the fungus. The so-called "greening" of the seed potatoes as practiced by some growers in the Greeley District is undoubtedly beneficial.

The treatment of cut seed should receive more attention than it ordinarily does. It is a well known fact that cut seed, allowed to stand for any considerable length of time, shrivels badly and the buds become weakened. Treating the fresh cut seed with air slaked lime, land plaster or sulphur tends to form a crust over the cut surface so as to prevent drying to some extent and they also tend to prevent the action of various fungi, worms and insects. These materials have not been experimented with sufficiently to know which of them is the best, but so far, observations of results have led us to favor the use of the flowers of sulphur as being more repellant to disease than the other two.

POTATO MACHINERY

The subject of machinery is one of general interest. All machines do fairly good work but none have been perfected. Nearly all the machines used in the state are made in the eastern states and are adapted to the conditions there. Some of the later models of planters are improvements on the older styles but none of them get a perfect stand of plants. Much depends upon the depth that it is desired to plant, and the depth of planting depends somewhat on the variety to be planted. Varieties differ consider-

ably in their habit of growth. Tubers are borne on root stocks or under ground stems that always grow from the stem of the plant above the old seed tuber. Figures 3, 1 and 2, Plate VI, show the characteristic habit of growth of Pearl, Rural N. Y. No. 2 and Improved Peachblow. The Pearl sends out short root stocks just above the old seed so that the tubers are formed closely around the center of the hill and at about the depth that the seed is planted. Rural N. Y. No. 2 has a longer rootstock and is apt to start higher above the old seed so that the tubers are more scattered in the hill. Some of them are deep in the soil and others will be close to or at the surface of the ground. The Improved Peachblow is still more irregular in its habit of tuber growth. These peculiar habits of growth make less difference under the hilling system of culture employed in the irrigated districts than where the level system is practiced.

With most machines the seed is planted too shallow rather than too deep. Many potatoes that are supposed to be planted four or five inches deep are really not more than one or two inches under the level surface of the soil. If the soil is sufficiently moist this does no harm but if the soil is dry at the surface, a poor stand is apt to result.

ROTATION OF CROPS AND RHIZOCTONIA

The rotation of crops as practiced in this state does not tend to lessen the amount of disease. The Rhizoctonia which causes the blight and a greater part of the scab of potatoes works on alfalfa as well as potatoes. So far as is known the disease does not live on the cereals so that is has been suggested that if potatoes could be preceeded by wheat or oats, instead of alfalfa, the amount of the disease might be lessened. The efficiency of a rotation of this kind is doubtful, however, as it is probable that the disease lives in the soil more than one year without any host plant, moreover the loss of the beneficial effects of alfalfa upon the soil would possibly be more than the ordinary loss from the disease.

SELECTION

A large part of the improvement in plants has been brought about through selection. This applies to plants propagated by vegetative parts as well as those propagated by seed. All the domesticated species are originated either from crossing or variations and are fixed in their particular characteristics by selection. The different varieties of a species may be called the variations of that species. When a variety is planted year after year it is sure

to revert or change its characteristics (that is run out) if selection of seed is not practiced. This is particularly true of a species that has such a great number of varieties as the potato. Varieties in this way are frequently subdivided into types. In a small way this may be seen in any potato field. A good example may be found in the Improved Peachblow. Some hills will be found that have from one to three large tubers with possibly a few very small ones. The large ones are apt to be cracked so as to be unsalable. Other hills may have one large tuber with several others grading down to the very small specimens. Now and then will be found a hill with from eight to a dozen medium sized perfect shaped tubers. Every man has in his mind an ideal type of the variety that he grows.

HOW TO SELECT SEED POTATOES

When digging, hills will be found, all the tubers of which will conform to this ideal. If these tubers be saved and planted, a large part though not all of them ought to produce potatoes like the seed. These should be selected again by hills and all should be discarded except potatoes from those hills which approximate the ideal type.

The longer this selection is carried on, the greater should be the proportion of tubers like the original selected type.

The usual objection to this selection, in practice, is that at digging time when the work must be done, the grower is too busy getting in the crop to take time for improvement of future crops. The selecting can be done, however, without taking a great deal of time. When the digger is running, one man should follow with a basket and select the most desirable specimens of tubers from hills that conform to his ideal type of that variety. Ordinarily the machine will leave the tubers in such shape that the individual hills can be separated. In this work do not look for perfect tubers only. Select perfect tubers from hills in which *all* of the tubers are of good shape and of sufficient number to give a good yield even though some of them are too small for market.

With this system of selection enough seed potatoes ought to be secured in one day to plant at least one acre of land. These potatoes should be sacked, *labeled* and put in a cool place by themselves. The following spring they should be planted at one side of the field where they can be staked off from the rest of the crop. Most growers prefer to plant potatoes, that are intended for seed, late. A very rich soil is not desirable for growing seed potatoes because of the tendency to produce overgrown tubers. This may be overcome to some extent by planting more seed to the hill or planting the hills closer together. When digging time comes the

same process of selection and elimination should be gone through again. In this way the improvement of type and yield may go on from year to year.

Many growers prefer green or immature seed to that which is fully developed. Experiments along this line with plants produced from seed rather than by vegetative parts have shown that immature seed tend to produce an early maturing plant and also one that tends to produce more fruit to the amount of plant tissue but at the expense of vitality and size of plant.

This law does not necessarily hold good with the potato since the reproduction is accomplished by means of the vegetative portion of the plant. Experiments along this line with the potato have not been carried far enough to give definite results.

COST OF GROWING

The cost per acre of growing potatoes varies to a considerable extent according to the soil, season and price of labor. One year with another an average of the different farms would not be far from the follwing figures which are taken from a pamphlet issued by the Greeley Commercial Club.

Plowing land	$2.50
Leveling and harrowing	1.00
Seed Potatoes	5.00
Planting	1.50
Cultivating	2.50
Irrigating	1.50
Digging	7.50
Sacks	7.50
Marketing	6.00
	$35.00

This estimate is based on what is considered a good yield or from 200 to 300 bushels per acre. The first six items are practically uniform, whatever the yield may be, while the last three depend upon the yield per acre, so that a poor yield or a failure, reduces the cost per acre by about one half and an extremely large yield increases it accordingly.

The price of Colorado potatoes has a wide range from year to year, but the average price for the past ten years has been 65c per hundred lbs.

Bulletin 118 January, 1907

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Western Slope Fruit Investigation

1906

REPORT

Field Horticulturist

By

O. B. WHIPPLE

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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The Western Slope Fruit Investigation.

INTRODUCTORY.

A delegation of fruit growers of Mesa county appeared before the State Board of Agriculture in December, 1905, and requested help from the Experiment Station in questions troublesome to fruit growers of that vicinity, especially along the line of plant diseases, insect pests, and, subsequently, damage from seepage.

The Associated Fruit Growers of Mesa county felt the need of the work sufficiently to pledge $1,500 toward the cost of such investigation. The conditions surrounding the Experiment Station did not permit its funds to be used for that purpose. Realizing the immediate need, the State Board of Agriculture decided to appropriate money from other funds to carry on the investigation for the year 1906, until the meeting of the Legislature, with the expectation that the Legislature would enable the work to be continued.

The investigation in a general way was to include two men, a Field Horticulturist, and a Field Entomologist, with headquarters in Grand Junction, and subsequently seepage investigations were undertaken. The Field Horticulturist worked under plans prepared by Professor Paddock, and reported directly to him; the Entomologist worked in connection with the Field Horticulturist and also worked under the plans prepared by Prof. C. P. Gillette. The seepage investigations were under the direction of Professor Carpenter, and were carried on by Prof. E. B. House and Mr. F. L. Payne.

Under the instructions, every orchard in Mesa county was to be visited as soon as possible, and inspected, particular attention being given to spraying, pear blight, crown gall, woolly aphis and all orchard pests, cultivation, drainage and irrigation, and in fact, all orchard operations, and an orchard survey was to be conducted at the same time, and an endeavor to get the history of each orchard as far as possible. In this way, it is possible to find the causes contributing to successes and failures, and to decide what practices have proven most successful. Blanks were prepared for the study.

In the seepage investigation, a detailed study was to be made of the location of the seeped lands, and an attempt to determine the cause, in order to be able to prescribe a remedy. While it was expected that several years would be required, the scope of the work expanded, and with the development arising from experience, a smaller part was completed than expected.

The Field Horticulturist at Grand Junction is Mr. O. B. Whipple, who was transferred from Assistant Horticulturist at Fort Collins to take charge of the work. The Field Entomologist is Mr. E. P. Taylor, a graduate of the State Agricultural College of Fort Collins, and formerly Assistant State Entomologist of Illinois, and in the seepage investigations, Prof. E. B. House, of the Experiment Station staff, and Mr. F. L. Payne of Wichita, Kansas, who had before assisted in conducting similar investigations.

This is a report of the Field Horticulturist to the Director for 1906. It was not originally intended for publication, but it is believed it will be useful, and therefore is issued as a bulletin. The other related reports are in preparation.

It is desirable that the work should be carried on for a series of years and should extend as soon as possible to other fruit growing districts, as desired by Professor Paddock and the fruit growers of the Western Slope, and this continuation depends upon funds available for the purpose.

L. G. CARPENTER, Director.

Report of the Field Horticulturist for 1906.

O. B. WHIPPLE.

My time as field horticulturist has been largely devoted to the study of orchard conditions in Mesa county. During the season I have made two trips to Delta county to investigate the conditions there. I find it nearly impossible to divide my time to any great extent with other counties. After more experience in field work under these conditions the work can, no doubt, be carried on over a larger territory. Very little experimental work has been undertaken during the past season as it seemed best to follow conditions in the field one season that we might take up experimental work more intelligently the ensuing year.

In my work I have given special attention to plant diseases, cultivation, watering, pruning and the collection of data on the fruit industry.

The interest taken in the work by the growers has been very gratifying, and at no time have we experienced any difficulty in securing the co-operation of careful growers in carrying on experiments. The success of our work depends to a large extent upon this friendly co-operation of the fruit growers. Our correspondence with growers has not been all we desired but will no doubt increase as we become better acquainted and the plan of our work better known. Requests for information have been numerous but on account of the limited time spent in the office, some growers have no doubt become discouraged in trying to reach us by telephone. I have tried to spend as many evenings as possible in the office where I hope the growers will learn to find me.

The orchard survey work has not progressed as rapidly as we at first hoped it would on account of the time required for other investigations. This survey has been carried on in connection with other work as far as possible. This part of the investigations can no doubt be pushed more rapidly during the remainder of the year, and, while the summer season is the ideal time for this work, I think the object of the survey can be accomplished during the winter season.

PLANT DISEASES.

Observations on plant diseases have been very interesting and some important conclusions have been reached.

ALTERNARIA.

Experiments were undertaken during the season to determine the best method of controlling this rot which was thought to be damaging the fruit and foliage of Keiffer pear and Ben Davis and Gano apples. Three orchards were selected where severe injury was reported during the summer of 1905 and experiments outlined. Inquiries among orchard men led me to believe that a part of this injury, at least, might be due to spraying, and the experiments were planned with this point in mind. In one orchard a block of seventy-five Keiffer pear trees was selected and divided into blocks I, II and III. Block I was sprayed with Bordeaux mixture (3-4-50) on April 14th. The buds were well started at this time and were out far enough to expose the individual blossom stems. This block was again sprayed on May 8th with Bordeaux mixture (2-4-50), with 3 lbs. of arsenate of lead added to each fifty gallons of Bordeaux for the first codling moth spray.

Block II was sprayed on May 5th and 8th with Bordeaux applied at the same strength and with the same insecticide as used in block I, and was again sprayed with the same material on June 8th.

Block III was sprayed with arsenate of lead only, during the entire season. On July 10th block II was divided, and half was sprayed with arsenite of lime while the remainder and all other blocks were sprayed with arsenate of lead. A light rain followed and black blotches on the fruit were quite noticeable by the first of August. All other blocks sprayed with arsenate of lead during the entire season were perfectly clean. This indicates that the injury in the part of block II sprayed with arsenite of lime was due to burning.

In the second orchard a block of fifty Keiffer pears and a block of fifty Gano and Ben Davis apples were selected for experiments. The block of Keiffer pears was divided into two blocks and block I was sprayed on May 8th, or just after the blossoms had fallen, with Bordeaux mixture (2-4-50) with two and one half pounds of arsenate of lead added to each fifty gallons of Bordeaux. The brand of arsenate of lead used was of poor manufacture, and on May 23rd the check trees making up block II and sprayed on May 12th with arsenate of lead only, were found to be badly burned, while the foliage and fruit of block I showed no injury. The injury on block II was mostly to foliage though some fruits were burned, most of which dropped early. Block I was saved by the excess of lime in the Bordeaux which combined with the free arsenic in the lead. A good grade of lead was used on all blocks after this spraying.

Block I was again sprayed on June 9th with Bordeaux mix-

ture and arsenate of lead. No further signs of burning or Alternaria rot appeared on either block during the remainder of the season.

The fifty Ben Davis and Gano apples were sprayed with Bordeaux on the same dates as the pears, leaving the remainder of the orchard as a check. The owner being anxious to get the first codling moth spray on at the proper time, applied it five days earlier. Both blocks were injured severely by this first spraying with lead. Most of the injured fruits dropped early and at picking time no injury from burning or Alternaria was noticeable on the fruit of either check or sprayed trees. On the shaded portions of large trees sprayed with Bordeaux a slight russeting of the fruit was noticed but not serious enough to cause damage.

The experiments in the third orchard were practically the same, only on a smaller scale. A good grade of arsenate of lead was used and no injury from burning or Alternaria rot was found at picking time.

With these experiments, and after observations in many other orchards the following conclusions were reached:

First; that Alternaria is in most cases a secondary factor in causing the decay of fruit.

Second; that it does not seem to be able to gain entrance to the fruit through healthy tissue, unless it be in cases where it enters the core cavity through the calyx tube, but may follow any injury, as spray burn, bruises or worm holes. During the season it has been found under these conditions, as well as on blighted fruit spurs of the pear and in the germ cavity of peaches with split pits.

Third; that Keiffer pears cannot be sprayed with any degree of safety with other than a standard make of arsenate of lead. The nearer mature the fruit, the more liable it is to injury, and if possible, no sprays should be applied later than July 10th. With thorough spraying early in the season, applications later than this date are unnecessary.

Fourth; that if Gano and Ben Davis apples are to be sprayed with arsenite of lime, special care should be given to its preparation and a good clear day selected during which to apply it.

PEAR BLIGHT.

Pear blight has been severe on many varieties of pears this season and many neglected orchards are practically gone. Where reasonable care is given to cutting out affected limbs, most varieties are doing well. By very careful cutting, many growers are proving that pear culture is still profitable. A great deal may be accomplished, I believe, in selecting varieties. Comparisons made during the season of pear orchards seeded to grass with those under cultivation seem to show little difference in the amount of blight.

The Flemish Beauty, Clapp Favorite and Idaho, fortunately three worthless varieties from a commercial standpoint, should never be planted, as they blight badly. Not only this, but trees of these varieties should be taken out. While it is possible that these varieties may be worked over to other varieties to advan-

tage, it seems very probable from observations of the season that sooner or later blight will get into the trunk and kill the tree. So often does this seem to be true in the case of the Idaho that it would seem advisable to discourage the working over of this variety. Some of the commercial varieties which seem to be most free from blight are Keiffer, Anjou, Mt. Vernon, Garber, Howell and Seckel. Le Conte, Sugar, Bosc and Sudduth, four varieties not so well known, seem to be quite free from blight. Unfortunately when once attacked, Bartlett seems to suffer quite severely. Winter Nelis is fairly resistant, while Clairgeau seems to suffer severely from attacks in the trunk and larger branches. Persistent cutting out, I think, will do much to save the pear orchards. If it does not pay to cut out the blight, it does not pay to grow pears and owners of badly infested orchards should pull them out. Many growers pronounce their pear orchards the most profitable piece of land on the ranch, but these are men who cut out the blight. The general practice with these men is to cut out blight at least three times during the summer.

Blossom and twig blight in the apple seems to be on the increase and has attracted a great deal of attention the past season. It has not only caused a loss of crop, but a great deal of anxiety in regard to the future of the trees attacked. However, the only loss seems to be in the destruction of the crop before it has set, and the killing of whole fruit spurs carrying blighted blossoms. Only in a few sweet apples and in very severe cases has the blight done any damage to larger limbs. The general tendency seems to be for the blight to kill the spur back to the branch from which it springs and then die out. In especially bad cases in Tolman Sweet we have found branches of one and two year old wood killed. Even where the fruit spur is hardly more than a bud, it seems to be an exception for blight to do any damage to the branch from which it springs.

There seems to be some difference in varieties as to their resistance to blossom blight. All the sweet apples blight badly. The Ralls, Dr. Walker, Wealthy, Pewaukee and Jonathan are also subject to severe attacks. No varieties seem to be immune in badly infected orchards, but the Winesap, Gano and Ben Davis are as resistant as any. However it seems hardly possible to give definite lists, for there are exceptions, and the tables are often turned.

"Twig blight" is also bad in some varieties, as the sweet apples, Jonathan, Pewaukee, Red Romanite, Willow Twig and Transcendent Crab. In this case the blight rarely affects more than the current season's growth. Badly blighted pear trees neglected by the owner of the orchard or a nearby neighbor were often found to be the original source of infection in these badly blighted orchards. With more careful cutting out of pear blight,

I think the blossom and twig blight in apples would tend to decrease. Some growers have trimmed out all blighted spurs and, while it improves the looks of the tree enough to pay for the trouble, I hardly think leaving these spurs would increase the liability to attack the following year, as by mid-summer all blighted spurs are thoroughly dried and it would seem impossible for any hold over blight to exist in them. I believe pear trees are, in the majority of cases, responsible for carrying the blight through to the next blossoming season.

PEACH MILDEW.

Probably owing to the unusual amount of rain during the early part of the season, peach mildew has been of more importance than usual. Losses from those of small per cents to those of total crops have been reported. Measures used in combatting this disease should be of a preventative nature rather than as a cure. After the fungus has once obtained a good foothold on the fruit, nothing can be done to save the peach. The fungus may be killed, but the flesh underneath refuses to grow and at ripening time we have a one sided peach or a peach with a sunken spot on it. The disease is capable of destroying a crop in a short time and prompt action is important.

Observations made in orchards where the attack was severe show that one thorough spraying with half-strength Bordeaux (2-4-50) will destroy the mildew. Thorough winter spraying of infested orchards with full strength Bordeaux should prove a very important safe-guard. The first appearance of the disease in early summer should be followed by prompt action on the part of the owner, and the orchard thoroughly sprayed with half strength Bordeaux. A week's delay in some orchards often means a loss of fifty per cent of the crop and two weeks a total loss.

GUMMOSIS.

Cases of Gummosis in peach trees have been found occasionally. Gum starts to flow from the trunk or larger branches during the early part of the summer and large drops are formed on the bark, often reaching an inch in diameter and are nearly as round as marbles. In severe cases the tree dies in the latter part of the season. While the number of cases reported need cause no alarm, the loss of a single tree in an orchard does not add to its value, and with reasonable care, I think the loss might be avoided.

While no large number of trees have been treated, experiments seem to show that a vertical slitting of the bark about the affected trunk or branch during the early stages will save the tree. Use a sharp knife for this work and do not be afraid of cutting too deep. Make the cuts about two inches apart. While I do not pronounce this a sure cure in all cases, it seems worthy of a trial on trees in the first stages. When the drops of gum reach the size of marbles, the tissues are broken down to such an extent that no practical method of treatment would save the tree.

ROOT ROTS.

Two apparently distinct forms of root rot are found. One form, which is proving the least destructive of the two, seems to show no preference for varieties, and confines itself to that part of the tree below the ground. The other seems to work exclusively on the Ben Davis and Gano, and the trunk as well as the roots are affected. The disease often extends upward into the large branches. The first indication of the disease is the appearance on the trunk of spots of a chocolate color. When peeled off the bark has a peculiar marbled appearance, the diseased portions standing out in sharp contrast to the healthy tissue. The disease soon kills the bark and it dries down to the wood, taking on a dark brown color. Two seasons are required for the disease to kill the tree. The first season the trunk is girdled and the foliage drops early. This early ripening of the foliage is often the most prominent symptom, and diseased trees can be easily picked out in the early fall. Trees showing an early bronzing of the foliage are generally found girdled by this disease. The second season the tree starts into leaf as the normal tree, generally setting fruit, and dies in mid summer, the fruit and leaves clinging. The disease seems to be infectious, as the trees appear in groups, and in many cases it appears as though it were carried by water. When a diseased tree is found, several more are generally found in the same row. However, other varieties besides the Ben Davis and Gano may stand in the same row with diseased trees on either side and show no sign of contracting the disease. The fact that Ben Davis and Gano are very tender as regards the application of arsenical sprays has suggested to my mind that the trouble may be due to arsenic collecting about the crown of the tree and killing the bark. However, the fact that trees sprayed with arsenate of lead and arsenite of lime are alike affected, seems to be contrary to such a hypothesis.

Prompt removal of the trees affected seems at present to be the only treatment that can be suggested. Reports indicate that the disease has only been in the orchards two or three years at the most. Soil conditions seem to have no relation to the disease, as it is found on all kinds of soils.

CROWN GALL.

Only a few cases of crown gall have come to my observation in Mesa county, a few trees having been killed by it. A disease which appears very much the same and no doubt the same disease that is called crown gall by other stations, seems to be doing considerable injury to the Vinifera vineyards of this section. Rose of Peru seems to suffer most severely. Muscat, Tokay and Cornichon have been found affected, however. When the disease attacks the crown of the plant, death seems to follow in one or two years. When the canes are affected, growth seldom starts from above the gall, but new growth starts from below and the plant keeps alive, but bears very poor crops. While it is probably transmitted from plant to plant in the vineyard, this is uncertain, but observations in the vineyards seem to bear out the statement.

I think it would be well to remove diseased vines and give closer inspection to nursery stock. Under the present system, grapes are passed without inspection.

PHYSIOLOGICAL TROUBLES.

Many yellow pear trees are found in the valley. Observations seem to indicate poor soil conditions, probably due in most cases to excessive watering. The foliage takes on a yellow cast, and in the last stages the leaves become thickly sprinkled with small deadened spots and fall from the tree. The trees grow more enfeebled from year to year and are finally pulled out.

SMALL PEACHES.

Many growers claimed that their peaches did not attain the customary size while they were very sure that they had thinned as carefully as in previous years. There is no doubt some truth in the assertion and also a cause. The peach trees were severely frozen in most localities during the winter of 1904-05. Not only were the peach buds killed, but the wood was damaged to quite a serious extent. Many of these trees were not pruned as heavily as they should have been following such a freeze, and did not make

a good recovery. The winter of 1905-06 was less severe and the fruit buds passed the winter safely. While the growers thinned their peaches as carefully as usual, the trees, having failed to fully recover from the severe freeze in one growing season, were unable to mature the normal crop. Where severely pruned, the trees matured their crop well. Following severe freezes which injure the wood, it would be well to thin the first crop more closely.

COPPER SULPHATE INJURY.

Copper sulphate has been placed about trees with injurious results by some orchard men. When taken up by the roots the material blasts the foliage and causes it to fall. The most telltale effect is a blackening of the outer ring of the sap wood and cambium. When taken up by the roots in a concentrated form, the wood and bark near the base of the tree are killed in strips of varying width. Nearer the top where the material spreads more, the tendency is for the leaves to drop, and later a new growth starts. The upper limbs probably recover. The strips of bark on the trunk and limbs, however, seem to be perfectly dead.

The stock solution used in spraying with arsenite of lime, prepared by dissolving white arsenic in water and sal soda, is very destructive to plant life. The general practice of keeping this solution in the orchard under a tree should be discouraged. If a small amount is spilled, or if the vessel leaks, the material will soon kill the tree. In fact, it almost appears as though in some cases the material will kill peach trees when placed under them in an open vessel. The fumes given off when boiling this solution will kill trees without a doubt, and this boiling should be done some distance from the orchard. I have seen trees standing twenty feet from an open packing house door killed on the side next to the packing house in which the material was boiled.

Some Ben Davis and Gano orchards have shown a very sickly yellow color during the summer, and investigations have shown that the trees were suffering from arsenical poisoning. The trees were sprayed with arsenite of lime in which the quantity of lime used was deficient, or with an arsenate of lead which contained a large amount of free arsenic. The growth of foliage is scant and the color yellow. Though the material may have been used only once, the effect seemed to last through the season. There seems no reason to believe but that the trees will recover the coming season.

THINNING APPLES.

Experiments were undertaken in thinning apples during the early part of the season. An orchard was selected in which large

blocks of Jonathan and Winesap were carrying a very heavy load. The thinning was done in the early part of July. The apples were actually counted on some trees and a definite number left. Assuming that from 150 to 160 apples of these varieties make a box of fancy apples, the trees were thinned to produce from six to twelve boxes. The trees were eleven years old and the best results on the Jonathan seemed to come from trees yielding eight boxes, running about 160 apples to the box. Trees bearing more than this, run smaller in size and less uniform. The Winesap gave better results when thinned to about six or seven boxes. Trees of Jonathan thinned to eight boxes would yield 95 per cent or over fancy fruits as far as size and color were concerned. Unthinned trees which packed about sixteen boxes gave 50 per cent of small fancy fruit, but on the days the thinned trees were stripped not 50 per cent could be picked from the unthinned trees on account of poor color. At least 25 per cent did not reach a good color. Thinned trees which picked twelve boxes required two pickings and run on an average about 90 per cent fancy. These trees averaged about fifteen feet in height and had a twenty foot spread.

Observations will be made next season on the thinned and unthinned trees to determine the effect of thinning on the ensuing year's crop. The rule followed was to leave only one fruit on a spur and remove those from the tips of limbs. Observations on unthinned trees showed that apples on the tips of limbs seldom reach a good size.

GRAPE GROWING.

The associations and growers have complained of poor results in shipping grapes. The trouble seemed to be that they molded before they got to market. Correspondence was taken up with California growers and observations carried on in the vineyards during the season.

From California rules, and from my own observations, I believe the growers use more water than is necessary. In one case, I actually found the bunches shriveling from excessive watering.

The reason some varieties do not ship well is no doubt because they are not ripe enough. The short season does not give them time to thoroughly mature. The California people say a grape must be ripe to ship well. Another point, I believe, is carelessness in packing, in not cutting out injured berries nor allowing the stems to wilt. Grapes packed tight while the stems are stiff crack easily and this gives entrance to mold. Owing to the method of pruning practiced to allow of easy covering, many of the bunches come in contact with the ground and should be thoroughly dried before packing. Experiments have been taken up to determine a more

satisfactory method of pruning which will hold the grapes off the ground and still allow of the vines being easily covered. The general tendency seems to be to prune too short, and light crops of inferior bunches are the result. No varieties should be pruned shorter than four eyes, and the Muscat, Sweetwater, Sultana, Emperor and Thompson Seedless should be pruned to eight. Some system of training must be found which will hold the fruit off the ground. More care should be given to watering. Three waterings, I believe, are enough. Dry soil conditions should prevail during the ripening period.

As to varieties, the Flame Tokay and Cornichon seem best adapted to the Palisade region where early frosts do not strike. For the rest of this district, Muscat, Rose of Peru, Tinfadel and Chasselas Victoria must be used. Flame Tokay may succeed on early soil where the soil conditions can be well controlled. Thompson Seedless, Sultana and Sweetwater do well, but do not sell.

Grape mildew (Uncinula spiralis) has caused some loss in vineyards, and experiments have been started this fall to determine the best method of controlling it. One block was given a fall treatment of Bordeaux before covering, and other blocks will be sprayed the coming season and various fungicides tested.

Experiments were undertaken to show the value of sacking Vinifera grapes to protect them from rots and mildew and to improve their appearance. The cost of sacking was found to be about one-half cent per pound for most varieties, while those producing larger bunches can no doubt be sacked at one-half this cost. The earlier varieties seemed to fare very well in sacks, unless they were subject to cracking, as some of the more tender skinned varieties are. Bunches in sacks laying on the ground split and molded badly. For the late varieties sacking proved to be a failure as it retarded the coloring and ripening and seemed to give no protection from frost. The stems were frozen the first frosty night and the bunches wilted and failed to ripen. The Muscat and Thompson's Seedless did very well sacked and their appearance was much improved.

SETTING YOUNG TREES.

Practically all the systems of laying out orchards and planting young trees are used in the fruit sections of western Colorado. The distance of setting varies from 16'x16' to 30'x32' for apples and from 12'x12' to 20'x20' for peaches, but the experienced growers are giving the greater distance.

The practice of setting Missouri Pippin, as fillers, in with the standard varieties of apples is quite common. In the peach districts peaches are often used for the same purpose. I hardly think the practice is to be encouraged, as the average grower will not take them out

before they crowd. The tendency is to leave them in until the shape of the other trees is ruined.

Trees as a rule are not handled carefully in transplanting and a larger per cent is lost than is necessary. The most common method of setting is to plow a furrow and with a little additional digging, set the trees in this. For the first watering, the water is generally run through this furrow. It is then filled, or left open for other waterings. Many leave it open the whole season, but it is generally thought best to fill it in and water from the sides before the sun gets too hot. The practice of leaving this furrow open for most of the summer seems to give good results, but there is a tendency, I believe, to set too deep. I think it a very good method if the furrow is very shallow. The most common method of watering is to fill this furrow after the watering at planting time, and run new furrows on either side of the row and as close as possible. This system will give excellent results if the man who is irrigating sees that water passes all the trees properly. It is possible to water trees too often, however, and the man who is inclined to water too heavy should keep his ditches at some distance from the trees. With a scant supply of water, the system of watering in the original furrow in which the trees were set will give the best results. Young orchards are either cultivated, or planted to secondary crops. The most common secondary crops are cantaloupes, potatoes, corn, oats and white beans. Cantaloupes do well on the lighter soils but other crops are generally sown on heavy soils. Oats is a poor crop for the young orchard, as it is generally cut just in time to force the grasshoppers to eat leaves and bark from the trees before frost. The cutting of any noticeable growth in the orchard at mid-season is a dangerous practice on this account. On sandy soils cantaloupes are proving a favorite crop. The furrows for watering the cantaloupes should be as far from the tree rows as possible that late watering of the trees may be avoided. This is very important in young peach orchards. Many inexperienced growers water their peach trees too late, and as a result, have them killed back during the winter.

Young trees are seldom pruned carefully enough after the first year, and long, willowy branches which bend to the ground with the first load of fruit is the result. Greater distance in planting should be urged and more care in regard to the forming of the young tree. Too many second class trees are set, the growers failing to realize that a poor tree is dear at any price.

GENERAL ORCHARD CONDITIONS.

It is a general practice among orchard men to water too much and neglect cultivation, and often the soil is handled very poorly. A large per cent of the soil is rather heavy to be handled well under

irrigation, and with the method of watering commonly used, it is often impossible to touch these soils with the cultivator from the first watering in early summer until the following spring.

It is often the case that shallow furrows and a large head of water are used and the result is a flooding of the whole surface. When dry enough to work again, the soil has run together and the surface is so hard that it is impossible to cultivate it, and the grower resorts to frequent watering to keep the orchard going. In these soils the water settles slowly and a smaller head run in deeper ditches would no doubt prove more satisfactory.

I think growers with these heavy adobe soils should also resort to the planting of cover crops to improve soil texture They could gradually be brought into shape where they could be more easily handled after irrigation. Growers, as a rule, pay too little attention to the sub-soil. Too often, the rule followed is, if you can kick up dust on the surface, irrigate. The appearance of the tree indicates to a great extent its needs, but after all, it is an examination of the sub-soil which most surely determines whether the orchard needs water or not.

General rules which it might be well for growers to follow in applying water are as follows:

The more sandy the soil, the greater the number of ditches, the shorter the run in both time and distance.

The longer the ditches, the larger the head.

The stiffer the soil, the fewer and deeper the ditches, the longer the run in time and distance, and the smaller the head.

PROBLEMS FOR THE ENSUING YEAR.

Some of the problems for the coming year as brought out by this season's work are as follows:

Pear Blight and its control, giving especial attention to the form known as blossom blight in apples.

Peach mildew and the effects of lime-sulfur wash as a winter spray in comparison with Bordeaux mixture.

Grape mildew (Uncinula spiralis) and its control and the effect of winter and summer spraying.

Observations on grape growing in general with reference to watering, pruning, packing and shipping.

Further study of the root-rots of apples to determine, if possible, the causes and remedies.

Bulletin 119 February 1907

The Agricultural Experiment Station

—OF THE—

Colorado Agricultural College

Western Slope Fruit Investigation 1906

Report of

The Field Entomologist

—BY—

E. P. TAYLOR

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1907

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

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WESTERN SLOPE FRUIT INVESTIGATION

Report of Field Entomologist*

SEASON OF 1906

E. P. Taylor, Grand Junction, Colorado

The principal lines of work for the season have been

(1) Experiments upon practical methods of controlling the principal insect pests of the orchard.

(2) Collection and study of other economic insects.

(3) Visitation of orchards by request or otherwise.

(4) Attendance at fruit growers' association meetings, farmers' institutes, county fairs, horticultural society meetings, etc., where questions relating to the work of this office were being considered.

The experiments carried on with injurious insects have been in cooperation with orchard men whose loss from these pests has invited tests of measures of control. The experiments have served as practical demonstrations in each neighborhood in which they were carried on, and have served as object lessons at the same time they were revealing new facts. They have been the objects of the deepest local interest. The territory covered by the demonstrative experiments has been thus far limited to points lying in the lower Grand Valley, principally in the orchard sections surrounding Grand Junction, Palisade, and Fruita.

CODLING MOTH. (*Cydia pomonella* Linn.)

Introductory—The codling moth has received the greatest share of attention. Spraying experiments have been completed in five orchards of the locality and the results successfully answer the principal questions relating to the control of the insect.

Probably no district in the United States is better equipped with modern spraying apparatus than the orchard district of Grand Valley. Nearly $100,000 are invested in spraying apparatus in the county of Mesa alone, but in spite of this fact, codling moth ravages have injured the fruit to the extent of a great many hundreds of thousands of dollars annually for some years past, and in spite of the fact that some orchardists have applied as many as ten or more sprayings per season. The past season has cost the growers, by careful estimate, over $36,000 for material used in making up their

*This bulletin is a companion to Bulletin 118, which gives the report of the Field Horticulturist for 1906, Western Slope Fruit Investigation.

The general plan for the entomological investigations were made by Prof. C. P. Gillette, and the work was under his direction.

The work was rendered possible by other funds than the government appropriations for the Experiment Station, a considerable portion from the fruit associations of Mesa County, and the remainder from the State Board of Agriculture.

arsenical sprays. This season's work has determined these failures to be due to several causes: (1) lack of thoroughness of method; (2) lack of proper spraying material, and (3) lack of knowledge of the exact life history of the moth.

The experiments demonstrated that this pest, the most important of all to the gruit grower of Colorado, may be conrolled by arsenical sprays applied properly and at the correct time.

The number of sprays required to control the moth in an orchard will depend principally upon (1) previous infestation of orchard; (2) proximity to other infested orchards; (3) efficiency of earlier sprays, and (4) variety of fruit.

To obtain results of greatest practical value to the fruit grower, orchard blocks of considerable size were chosen and given treatment in the most thoroughgoing and intelligent manner. Records of every detail were tabulated, and at the close of the season, in determining results, very large numbers of apples were given hand-to-hand inspection. For example, over 100,000 apples, representing upwards of 600 bushel boxes, were given a most critical examination to reveal, as nearly as possible, the exact outcome of the experiment.

Life History Studies—A study of the life history of the moth carried through the season showed many things of vital importance relating to the proper time to spray. No great variation or change of habit of the moth was noted. The time required for the passing of each stage of the insect was practically identical with other observations of the insect in the state. The time or dates of transformations of the moth were found, however, to be much earlier than for the majority of the other fruit sections of Colorado, and some variation exists between the different portions of the Grand Valley, transformations taking place earlier, as a rule, in the region about Palisade than in the country surrounding Grand Junction or Fruita.

Parasites—Natural parasites of the insect were studied, one of the most interesting being the minute bee, *Trichogramma pretiosa,* laying its eggs and developing within the tiny egg of the codling moth.

Bands—The use of bands is not discouraged, but they can not be depended upon alone to control the moth. If used, the old ones which have remained on the tree through the winter should be cleaned up by April 1st to prevent larvae from changing to pupae and moths making their escape. They should also be gone over at least every ten days through the summer until the middle or latter part of August, after which there will be little danger of moths emerging until the following spring.

Spraying Experiments—As stated, spraying with arsenicals was the standard remedy adopted, and the studies were made upon (1) Time to spray; (2) Kind of spray, and (3) Way to spray.

Time to Spray—The time to apply the first spray in the experiment conducted was determined by the condition of the calyx of the bloom, and that of the later sprays by careful and systematic observation for the appearance of the eggs of the moth.

Close observation of the calyx will determine when it is in an

ideal condition for spraying. This time should be following the dropping of the petals but before the closing of the calyx. A period not to exceed from five to seven days for any one variety would cover the time when this first spray should be applied. Sprayed too early or before the petals are fallen, bees about the bloom are in danger of being destroyed, and, sprayed too late, the green sepals will have come together at their tips, closing the calyx cup against all possibility of being filled with the poison.

The center blossoms are invariably the first to open their petals and first to drop them. They are first to close their calyces and most likely to set fruit which will remain without dropping from the tree. It is therefore evident that this first spraying should be done with these blossoms in mind. The first eggs do not appear for several weeks later. When the young larvæ hatch from these eggs, the larger per cent of them enter at the calyx, and if the first spraying has left the calyx containing a liberal amount of poison, their first meal will, in all probability, be their last. Sixty per cent or more of the first generation larvae, according to this summer's observations, entered at the calyx. For the remaining forty per cent or less entering at the side or stem end of the apple, a second spray must be applied early enough to coat the surface of the small apple with poison before the hatching larvae make their appearance, and this coating must be maintained upon the fruit until the first generation's eggs have hatched.

Other conditions being right, two sprayings with an adhesive arsenical will perform this end, and the first generation thus practically destroyed. There being but two full generations of the insect through the season, if the first be destroyed there should be no second left with which to contend.

As stated above, however, in common practice there will be cases where more than two sprays are necessary, and these additional ones should be directed against the second generation.

Any one may determine the proper time to spray by observations upon time of egg appearance, though in practice this is more or less difficult for the average orchardist.

The date of appearance of the blossoms upon fruit trees is dependent upon meteorological conditions for the spring. These same conditions regulate the initial appearance of the adult moth, and as its times for transformation are fairly constant thereafter, it seems possible that a general rule may be made for common use, based upon the blooming of the fruit in spring. Such a general rule is herewith presented, thought to be dependable, at least in the general locality wherein it was determined, and if conclusions above stated are correct, the rule should apply for other points as well. Observations upon the time of appearance of the insect in any of its stages could be made to supplement the general rule. The efficiency of the first two sprays suggested will largely determine the necessity of the later sprays. The dates given are those applying to the blooming and spraying of Jonathans at Fruita this year, and should be considered

as subject to variation with place, season, and variety. The egg observations were made upon trees receiving no treatment throughout the season.

HOW TIME TO SPRAY WAS DETERMINED IN EXPERIMENTAL ORCHARD.		TIME TO SPRAY—GENERAL RULE.
Petals dropped—calyces open	May 11	
First spray	May 11	(1.) Petals off-calyces open.
First eggs seen	May 21	
Numbers eggs seen	June 1	(2.) (*a*) One month from full bloom. (*b*) Three weeks from center calyces closing. (*c*) When apples are about ¾ in. diameter.
Second spray	June 2	
First generation, eggs maximum	June 13–19	
First generation, eggs minimum	June 28	
Second generation, eggs begin	July 2	
Third spray—(suggested)	July 2	(3) One month from (2)
Second generation, eggs abundant	July 17	
Fourth spray—(suggested)	July 18	(4) Two weeks from (3)
Second generation, eggs maximum	July 25–31	
Fifth spray—(suggested)	August 1	(5) Two weeks from (4)
Second generation, eggs diminished to about	Sept. 1	

The time in which an orchard must be completed with the first spraying will be of greater importance than the time required for second or other later sprays. Power spraying outfits make it possible to cover larger orchards in less time than with hand apparatus, but it has been found that under ordinary conditions one good power outfit should not be expected to cover more than twenty acres of full-bearing orchard at the first codling moth spray.

In apple orchards of mixed varieties those blooming first should be sprayed first. Pears do not close their calyces as quickly as apples, and their first spraying may be longer delayed.

Kind of Spray—The experiments of the year demonstrated that Swift's arsenate of lead was slightly superior to the arsenite of lime so far as killing effect upon worms was concerned. The difference seemed to be less than 4 per cent, but though the cost of the lead is considerably more, it is probable that with a heavy yield of fruit of high market value the lead would probably more than pay for the difference in cost. It is more convenient and less liable to injure foliage. Other brands of arsenate of lead were used with nearly equal success in controlling the worms, but some samples had been improperly made and caused injury to foliage and fruit from an excess of free arsenic contained. Arsenite of lime, used with sufficient lime, will

cause no injury to trees under ordinary conditions, though it is more liable to do injury than properly made lead arsenate. Injury to trees from arsenical sprays is more or less dependent upon variety of fruit and meteorological conditions at time of or following spraying. A practice among some orchard men the past season in Mesa County has been to use arsenate of lead for the first and second sprays, and if further spraying is found necessary the cheaper arsenite of lime is substituted.

Arsenate of lead was used at the rate of 12 pounds paste per 200 gallons of water in the experimental orchard.

Arsenite of lime was used at the rate of 1 pound arsenic, 4 pounds sal soda, 30 pounds lime per 200 gallons of spray, the arsenic and sal soda being boiled together in a small quantity of water for fifteen minutes until dissolved, after which the lime slacked with water to form a milk was added.

Both arsenate of lead and the arsenite of lime sprays, from their white coating upon the leaves, produce a shading effect, which in our arid climate serves a secondary beneficial effect by reducing transpiration by the foliage.

Method or Way to Spray—In the experiments of the year it was shown that the method of application had more to do with success than a difference of the insecticides used. The variation between poor spraying and very good spraying might well vary between 20 per cent and 98 per cent, while, as shown, the two insecticides showed variation of only about 4 per cent.

For the 12-year-old apple trees in the experiment at Fruita, an average of 12.9 gallons of spray was applied per tree for the first spray, and 9.9 gallons were used for later ones.

For the early spraying a coarser spray of liquid, such as would be given by a Bordeaux nozzle or a coarse Vermorel nozzle cap, is desirable. At this spraying the tree should be drenched with a strong, driving, coarse spray. It should be directed straight into the calyx cups that a maximum amount of poison may be placed in position there. It was determined by actual count that at spraying time average apple trees had two-thirds of their blossoms pointing in an upward direction and one-third in a downward direction. It is, then, apparent that spray must be directed downward upon the tree as well as upward through the branches. It was found necessary with full-bearing trees, in order to insure thorough work, that spraying be directed downward from the top of a tower constructed over the spray wagon. Where power outfits are used, and where the rows are of such a distance apart that the inner halves of any two can be treated from a point midway, it will be found that on medium to large trees two men upon the tower and one man spraying upward from the ground will be found most satisfactory. Spray poles eight to twelve feet long should be used by both ground and tower men. In one of the experimental orchards the height of tower man's reach was twenty-five feet above the ground.

For the later sprays, a nozzle producing a fine mist is desirable. A nozzle of the double-vermorel type, arranged in such a way that the direction of the nozzle can be placed at any angle with the spray pole, is wanted. The size of aperture wanted in the nozzle cap will depend upon the pressure maintained. The higher pressures can be directed through larger apertures and still produce as fine a spray. Higher pressures economize upon material and time, and under ordinary conditions are most desirable.

In the experiment conducted upon the orchard of Mr. G. W. Marchant, of Fruita, two sprayings with Swift's arsenate of lead (12 pounds per 200 gallons) applied at the times indicated in the above table, and in a thorough manner, produced 98 per cent winesap, 95.6 Ben Davis, and 91.8 Jonathan apples free at picking time from all worm holes. Picked, unsprayed Jonathans in a block in the same orchard gave only 43.1 per cent free from worm holes, and 49 per cent of the apples, by actual count, originally borne by the trees, had fallen to the ground, 96 per cent wormy before picking. Only 15 per cent of the total crop of sprayed Jonathans fell to the ground as windfalls, and 74.1 of these were perfect apples. The apples in the sprayed plats were treated with a repetition spray following a heavy rain, though by comparison with plats left untreated with such spray it was found that the additional or repetition spray was unnecessary.

The complete details of this summer's experiments and observations upon the codling moth will be available in a special bulletin issued by the Colorado Agricultural Experiment Station, which bulletin is now under preparation.

HOWARD SCALE. (*Aspidiotus howardi Ckll.*)

This pest is one of greatest importance to the pear growers of parts of Colorado. Besides the pear, it is known to infest prune, plum, apple, almond, and certain shade and forest trees.

The life history of the insect was partially worked out during the year and experiments conducted showed the insect to be possible of cheap and complete control by spring applications of the lime and sulfur wash.

As a bulletin is also soon to be issued upon this pest and its remedies, based principally upon this season's investigations, details of the work on the insect may be ommitted in this general report.

PEACH TWIG-BORER. (*Anarsia lineatella* Zell.)

Introductory—Experiments conducted at Palisade have demonstrated the great value of arsenate of lead against the twig-borer of the peach, which caused considerable damage to the peaches in this and other localities of Western Colorado.

Former recommendations for the control of this insect have been for spring applications of lime and sulphur washes. This has in fact, been a most successful treatment, but the use of lead arsenate against the twig-borer of the peach is destined to meet with equal popularity when its efficiency, cost, and convenience of preparation and application are considered.

The peach twig-borer is one of the most important pests to the peach growers of Western Colorado. All of the peach spraying carried on in the Grand Valley the past spring was directed against either the peach aphis or the peach twig-borer.

It is estimated that this pest cost the peach growers of California over a million dollars in the four years following 1898. To the growers of Grand Valley it has cost much loss for some years past, and its distribution on the Western Slope of the state seems to be quite general wherever peaches are grown.

Life History and Injury- The injury is caused by a small pinkish brown worm, with black head, measuring, when fully grown, about one-half inch long. The worm is the larval or immature stage of a small greyish moth.

The winter is passed by the larvae, still very minute, in small chambers hollowed out within the spongy tissue of the bark at the crotches of small limbs. The chamber is lined with silk of the larva's secretion, and the only evidence of the presence of the chamber is in a very small and inconspicuous heap of frass or peach-wood dust standing outward from the mouth of the burrow. Early in the spring, at about the same time the foliage of the peach shows as small green tufts upon the twig tips, the larvae leave their burrows and attack the tender twigs, boring into them near their tips and down through their pitch, forming galleries from one-third to one and one-half inch in length.

Examinations of infested peach trees at Palisade last spring showed these bored twigs wilting and turning brown early in the month of May. Later in the season, twigs bearing half a dozen leaf tufts near their tips would have each bored and killed and from all appearances by the same larvae. This injury to the terminal twigs constitute an important injury to the tree. Young peach trees are usually worst infested, their growth being sometimes greatly retarded.

On the 18th of May a number of larvae were taken in peach twigs at Palisade and kept in water in a closed cage at my insectary. An examination of the cage May 24 showed that two of the larvae had already changed to brown chrysalids or pupae, both emerging on May 28.

On May 20 many larvae were also found concealed about the base of the tree at the surface of the earth and hiding about the bark, and it seems that at this date the majority of the larvae, which hibernated over winter in the small bark cavities, have now completed their feeding on the twigs and are descending for pupation. As stated, the usual habit of the first or hibernating brood of larvae is to burrow into the twigs. A few instances were found, however, where small peaches, still no larger than a pea, were burrowed into, leaving the fruit with a hollow cavity within.

The small second generation worms were seen beginning their work early in June. It is this generation which brings about another and by far the greater amount of injury to the peach crop. Larvae from this generation make their way directly into the forming peach

itself, and the "gummy" peach is the result. Projecting bits or masses of exuded gum appear on the surface, and from their appearance and impaired keeping qualities they are rendered unfit for market. Some peaches containing larvae of the twig-borer find their way into boxes to be marketed on account of having the borer deep in the peach or within the pit without external signs of habitation. Such fruit, however, is first to soften and decay, and should be excluded, if possible.

Control—At Grand Junction last spring I received many inquiries from peach growers as to the best measures of twig-borer control.

So far as published accounts were available, contact insecticides, such as kerosene emulsion or lime and sulfur wash, were the ones considered most effective. The previous spring Mr. Frank Berger, of Palisade, and a few other growers of that place, had used arsenate of lead as a spring spraying, instead of the lime and sulfur wash ordinarily used, and reported no injury from twig-borer following. As none of these orchards had portions left with no spray, I could not determine for certainty whether the favorable results reported by these orchardists was due to the effectiveness of the spray or to the lack of original infestation by the twig-borer.

To determine this it seemed necessary to prove the value of the arsenical spray by an experiment carried on in an orchard where a considrable portion was left untreated, which was done in the five-year-old peach orchard of ninety-two trees belonging to Mr. S. L. Carson, at Palisade, where a portion was sprayed with arsenate of lead, another with the lime and sulfur wash, and a third part left with no spray. The arsenate of lead was used at the rate of 5 pounds of the paste to 50 gallons of water. The lime and sulfur wash was used at the rate of 15 pounds lump lime and 15 pounds flowers of sulfur per 50 gallons of water, the two ingredients being boiled together in a small amount of water for forty-five minutes, then diluted with enough cold water to make fifty gallons of spray. The spraying was done with a hand pump and sprayed trees thoroughly coated over all bark and twig surface. The two sprays, as applied, were of about equal cost—each a trifle over 1 cent per gallon, exclusive of cost of preparation. The arsenate of lead spray was far less inconvenient, and was quicker in preparation, and was also more pleasant to prepare and apply.

The spraying was done on April 14, at which time the majority of the blossom buds showed their pink tips, but as a rule were unopened, with the essential parts of the blossom still concealed by the folded petals of the flower. Some varieties, however, in each plat were farther advanced and some with as many as 87 per cent of the blossoms open.

The comparative insecticidal values of the two sprays were apparent through the season from the number of injured twigs per tree, and also from the number of gummy peaches per tree occurring upon each plat.

A striking difference was apparent when the number of injured twigs per tree were brought into comparison by observations made in May and shown in the following table:

A COMPARISON BETWEEN LIME AND SULFUR WASH AND ARSENATE OF LEAD AGAINST PEACH TWIG-BORER.

Spray.	Date Sprayed.	No. trees sprayed.	No. trees examined.	Date examined.	Total No. injured twigs counted.	Average No. injured twigs per tree.	Per Cent. Benefit.	Conclusions.
Lime and Sulfur....	14 Apr.	38	17	0-18 My	72	4.23	90	Good.
Arsenate of Lead..	14 Apr.	33	16	"	20	1.25	97	Better.
Check	No spray	18	8	"	342	42 75	0	

Circumstances prevented the keeping of an exact record of the number of wormy peaches taken from each plat, but a very noticeable difference was noted at time of picking—a difference quite as marked and corresponding in results with the figures shown in the above table. In fact, the owner of the orchard invariably picked the wormy peaches from the plat not treated and found scarcely any fruit damaged in either of the plats sprayed.

It may be said that arsenate of lead, applied in the spring at the time the buds of the peach are beginning to open, will control the peach twig-borer as effectually and cheaply as the lime and sulfur wash, up to this time the most universally used.

Any arsenate of lead spray applied to peach trees must not contain free arsenic, as they are easily damaged by impure lead or lead diluted with water to contain too high a per cent of the poison, though pure. Growers using 3 pounds lead per 50 gallons water were equally successful, and from the susceptibility of peach to injury, this latter strength is recommended, instead of the stronger spray used in the experiment reported above.

PEACH-BORER. (*Sanninoidea exitiosa* Say.)

Distribution—This dangerous insect has been found present in some peach orchards of the Western Slope.

Our species is the same as the one found in Eastern states, causing such widespread damage to peach trees. It is evidently a pest which has come into the orchards along with nursery stock brought to us from some infested part of our country

Injury and Life History—The injury is one resulting from the burrowing of a yellowish-white larva, which, when fully grown, sometimes measures one and one-fourth inches in length. Signs of the presence of the borer are the gummy exudations coming from the crown of the tree at the top of the ground. Infested trees examined early in the summer showed larvae of sizes varying from one-fourth to one and one-fourth inches in length. Some small larvae were then barely concealed beneath the peach gum on the outer bark.

Other larger larvæ were within extensive chambers, extending up and down through the wood sometimes an inch beneath the bark. Trees badly infected are completely girdled and killed. The insects spend the winter as larvæ, and in the early summer change to pupæ within a brown cocoon or cell from seven-eighths to one inch long by one-fourth to five-eighths inch in diameter, usually projecting into or from the gummy mass at the base of the tree. The first pupa was found formed within these cocoons on the 27th of June, though the majority were being formed about the middle of July. The pupæ yield moths, the females of which are of a blackish brown color, with partially transparent wings and a black body circled at about the middle with a beautiful orange band. The males are smaller and more slender than the females and have a number of smaller, less conspicuous bands of yellow about the abdominal segments and with more nearly transparent wings. The first moths appeared on July 6, though the maximum number were not appearing until about August 11, a singular fact, since these moths are known to come out in greatest numbers in New York state and at Washington, D. C., from one and one-half to two months earlier in the season. Eggs are laid upon the rough bark about the crown of the tree. The eggs, when laid, are oval and of a brown color. Large numbers are deposited by each female. On August 6, a single female gave by dissection about 300 eggs, 150 of the number at that date being brownish in color and well formed, while 150 were white and still embryonic in nature.

Experiments Begun.—Its importance made it seem advisable to test remedial measures, and various old and some new methods of combatting the pest were begun in June, and the final results are still pending.

Following are the measures under comparison in the experiment:

(1) Carbon bisulfide, 1 ounce per tree about crown.
(2) Tobacco dust, 2 pounds per tree about crown.
(3) Tarred felt and wire shields about base of tree.
(4) Lime dust, 2 pounds to 4 pounds per tree about base of tree.
(5) Dirt removed and larvæ removed by hand.
(6) Banking earth about tree's base.
(7) Tree washes.
(8) Trees not treated in same orchard to be used as comparison.

GREEN APHIS OF APPLE. (*Aphis pomi.*)

Importance.—The unusual abundance of this aphid the past season upon apple and occasionally upon pear on the Western Slope has made it necessary to make observations upon and carry out insecticidal tests against it.

Life History.—The green aphis winters as eggs upon the twigs of the tree, and the past spring a very large per cent withstood the winter. They began hatching about Grand Junction about April 1, continuing for two weeks or more. The young hatched at about the same time the first traces of green foliage appeared, and thus found tender food upon which to feed at once.

In the latter part of April winged insects appeared and a general spreading of the pest from tree to tree and orchard to orchard took place. Multiplication was enormously rapid. The injury continued to increase in severity through the summer. Lace wings and syrphus fly larvæ, as well as the adults and larvæ of lady beetles, served to do much good later in the season, but did not succeed in reducing the aphids enough to prevent great injury. Eggs of the green aphis were first found in the fall at Grand Junction on October 16. When first laid, the eggs are green, but finally turn to a glistening black.

Injury—They have been a great hindrance to the growth of young apple trees set the past spring or the preceding year, and older trees have not been exempt from their attacks. Missouri Pippin apples of all ages have suffered heavily, the aphis apparently preferring this variety to any other common in the Valley of the Grand. Badly infested trees through the summer present a most disgusting appearance, the aphids becoming so numerous that the whole tree assumes a sticky coating of the secretion from the bodies of the insect. This "honey dew" secretion attracts swarms of flies and ants, and the trees often emit a very disagreeable odor.

The effect upon the tree, if young, is a severe retarding of its growth. A form of injury noted this season, thought to be due to this insect, was an odd and greatly deformed growth of the fruit itself. Nero and Winesap apples were found affected in this way. The young apples, when only from one-fourth to one-half inch in diameter, had been so thickly covered with aphids that their growth had been suddenly checked. Later on, their growth had been resumed principally from the outer end of the apple, producing what might be called a "double apple," with a constriction at the middle point. Other apples were caused to grow in greatly gnarled or knotted forms. All were greatly dwarfed in size, seventeen Winesap apples at harvest time being contained, in one instance, within a common match box.

Treatment—Trees heavily infested had their leaves tightly curled, due to the presence of myriads of the aphids upon their under surfaces. With the aphids thus concealed within the curled leaves, it was found almost impossible to cover their bodies with any contact spray applied, and the practice of summer spraying against them was anything but a success. Individual trees were, in cases, cleared up, but other trees near by and left untreated usually very soon reinfested them.

Spring and early winter treatments were also carried out in experiments against this insect.

The spring spraying was directed against the eggs of the pest and gave the best promise of its successful control. In an experiment with a number of contact sprays applied April 5, just after the eggs had begun to hatch, it was found that the lime and sulfur wash proved the most successful. In this instance, 15 pounds of lime and 15 pounds of sulfur per 50 gallons of water were used, and practically all of the eggs and hatched aphids were destroyed.

In December, kerosene emulsion and soluble petroleum sprays were tried on infested trees, and the per cent of eggs destroyed at time of hatching this spring will be determined. Further experiments for the control of this pest are planned, including a large series on contact insecticides to be used this spring.

WOOLLY APHIS. (*Schizoneura lanigera.*)

Importance.—Probably more important to the fruit growers of Western Colorado than the green aphis is the woolly aphis of the apple. The pest on the peach has ranked second only to the codling moth in destructiveness in the Grand Valley, and has been of first importance in other counties of the Western Slope.

Life history.—Many breed through the winter upon the roots of the apple, and a few survived the winter upon the branches above ground. During the winter of 1905-06 the temperature at Grand Junction according to the United States Weather Station, did not drop as low as the zero point, and the unusually mild winter perhaps had much to do in the great abundance of the insect this past summer.

In May many of the aphids above ground had already secreted their woolly coverings of white, and in cases heavily infested the water sprouts about the base of the tree. By the month of July, countless myriads of them were to be seen crawling over all parts of the tree and fruit, as well as upon the ground through the orchards. Winged ones were noted first at Fruita September 6.

Parasites.—Parasites have done some service in helping to keep in control the pest, but have not been abundant enough to reduce the number of insects to a point below injury. Lace wing and syrphus fly larvæ, as well as adults and larvæ of lady beetles, have been most prominent in preying upon this aphis. Some observations upon the habits and life history of these parasites have been made.

Injury.—Roots and tops were attacked throughout the season, the twigs being sometimes entirely coated with the woolly secretion covering the bodies of the insects. Such infested twigs were greatly dwarfed, the bark on the twigs caused to split and grow in a gnarled and misshapen form. The "honey dew" secretion from the insects in some cases coated over the peeling of the fruit itself, leaving the surface so sticky and discolored that apples were disgusting in appearance and most unpleasant to handle. Grafts and top-worked trees suffered most heavily in the spring, and their injury continued through the summer.

So thick were the insects upon the branches that apple pickers working in the trees had their clothing covered with crushed bodies and the white secretion of the insect.

Roots about the crown of the trees were gnarled and knotted, resulting in the dwarfing of the trees, the production of undersized fruit and in exaggerated cases, the outright destruction of the trees themselves.

Remedies or Progress.—Summer sprays, as with the green aphis, where the infestation was so severe and so general through the orchards, proved of small practical value.

This pest is of such importance that careful and exhaustive experiments of measures of control must be carried out against them without delay. In the fall and early winter a long list of insecticides were applied to infested trees, and the list will be duplicated this coming spring, and it is hoped that by the coming fall some practical suggestions upon an effective method of control of the pest may be reported. Tobacco and carbon bisulfide upon the roots of the trees, and kerosene emulsion, whale oil soap, and tobacco decoction sprayed upon the tree have been the previous practices of treatment by orchardmen. These measures, soluble petroleum sprays, tree tanglefoot bands and many other methods of control will be given thorough trial.

A NEW INJURY TO PEAR AND APPLE BUDS.

Description—On the 4th of May, an injury to buds of pear on grafts placed into pear stocks about one month earlier was observed. Attention to the injury had been called by the owner of the grafted trees, who had observed that his grafts, which should have been starting readily off into growth, were being held back by some insect, which apparently was eating away the buds as soon as they started to grow.

Examination on May 4 showed the injury to be caused by a tiny chrysomelid beetle (*Myochrous squamosus* LeC.) greyish-brown in color and less than one-fourth inch long. No published accounts of injuries of this kind from this beetle have been found, and it is probable that this observation of injury is the first recorded against the beetle. It caused enough trouble, however, to require some remdial measures. Unless something had been done greater damage would have resulted, and, as it was, some of the attacked grafts were destroyed by having all buds eaten away.

The beetles were discovered about the bases of the grafted pear trees, hiding beneath clods and in crevices of the earth. The principal injury was done to pear buds, though specimens were also taken feeding upon the buds of apple borne by twigs near the ground. Beetles were also found beneath clods about the apples. Not only did the beetles attack the buds upon grafts, but they were found eating into the pear leaf and fruit buds high up into the tree. In one instance, a beetle was watched eating away the petals of an open pear blossom. Search was made about the trees for a weed or plant which could have served as a natural food plant for either adult or larvæ, but none was found. As many as a dozen beetles were, in cases, collected about the grafts of a single small tree or about the base of the tree. The injury continued through the month of May, and beetles kept in cages at my insectary were kept alive through the month of June. Many of the beetles were found floating on the water in irrigating ditches late in May, and later adults were taken hiding beneath bands placed upon trees to capture codling moth larvæ.

Control—Several measures of control were suggested or used. A spray of arsenate of lead applied to the buds was tried and thought to have been of considerable benefit. The owner of the orchard prac-

ticed hand picking of the beetles, but the process would be entirely impracticable upon any number of trees. The winged beetle appeared to be more of a crawling insect than a flying one, which suggested the possibility of protecting young grafts by placing bands of "Tree Tanglefoot" or other adhesive bands about the tree trunks to keep the beetles from ascending in the spring.

MISCELLANEOUS OBSERVATIONS.

A great many other injuries to fruit or field crops by insects, rodents, etc., were observed through the season.

A pink bodied aphis of undetermined species was found doing considerable damage to peach buds, blossoms, and young fruit early in the spring. Specimens were first seen April 13, at which time peaches were showing first bloom. The larger, flat-bodied, pinkish aphis first observed gives birth to young, which cluster about the blossoms and about the forming peaches, still very small, sucking from them the sap and causing many to fall to the ground. Later in the season, peach leaves are curled up by the aphids, but all seem to disappear late in May. The injury is thus done early in the season at the time fruit is setting. Application of the lime and sulfur wash just before the buds open is suggested as a means of control, and this and other measures of treatment will be tried in an experimental way the coming spring.

Observations were also made upon aphids infesting plums, elms, and poplar.

Injuries to cantaloupes were noted, caused by leaf miners, the common red ant of the prairies, and prairie dogs. In some orchards the green fruit worm caused injury to from 10 to 25 per cent of the young forming apples, but in orchards receiving proper codling moth spraying the injury is much less severe or reduced beneath notice.

A pear leaf blister mite, probably of a different species from that causing the injury in Eastern States, was observed in great numbers through the summer, causing the blackened curling of the pear leaves at the tip of the twigs, as well as producing minute blisters upon the leaves and causing them to drop from the trees prematurely. It is thought that a late spring spray with the lime and sulfur wash will also control this pest.

Other orchard pests observed, studied, or experimented upon in attempt at control were the buffalo tree hopper, tent caterpillar, hawk moth larvæ, grasshoppers, thrips, brown mite, pear and cherry slug, terrapin scale, Putnam scale, and numerous parasitic or predaceous insects doing beneficial service in the orchards.

Bulletin 120 July 1907

The Agricultural Experiment Station

—OF THE—

Colorado Agricultural College

The Howard Scale

—BY—

ESTES P. TAYLOR

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1907

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

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THE HOWARD SCALE.

Aspidiotus howardi Ckll.

—BY—

ESTES P. TAYLOR

INTRODUCTION.

The extensive injury wrought in parts of the State of Colorado to pear, prune, plum and other fruit and shade trees by this insect makes it one of especial interest to the horticultural industry at this particular time. Further, the pest is the nearest ally of San Jose or Chinese Scale, well known as the most destructive of all fruit tree enemies.* The Howard Scale is one of peculiar importance to fruit growers of this state since its first discovery was made in Colorado and fruit growers of no other state as yet consider the pest with the same degree of interest. So far as is known, two states only, Colorado and New Mexico, harbor this insect.

The history of the insect is all of comparatively recent date. It was first discovered by Prof. C. P. Gillette at Canon City, on March 31, 1894, upon the fruit and bark of prune and wild plum. These first specimens were sent to Dr. L. O. Howard of the Bureau of Entomology, U. S. Department of Agriculture and to Prof. T. D. A. Cockerell, then of the New Mexico Agricultural Experiment Station, but now of the State University of Colorado at Boulder. Dr. Howard pronounced the insect a new species and Professor Cockerell applied to it the name Howard scale.*

Professor Cockerell later encountered the scale at Albuquerque, New Mexico, in August 1895, upon the fruit of silver prune which determination was verified by Mr. Pergande of the U. S. Department of Agriculture, from material furnished him.

The next published mention of it is from Professor Gillette in the Annual Report of the Experiment Station for 1901 when he reported its occurrence for the first time upon fruit trees of the Western Slope. Mr. H. E. Mathews, horticultural inspector for Delta county had, during that season, sent specimens of the scale taken from pear and

* A most exhaustive and complete treatise on "The San Jose or Chinese Scale" has recently been issued by Mr. C. L. Marlatt as Bulletin No. 62, Bureau of Entomology, U. S. Dept. of Agriculture. This bulletin should be in the hands of every Colorado fruit grower. It may be had by application to the U. S. Dept. of Agriculture, Washington, D. C.

* The original description was published in Canadian Entomologist, XXVII p. 16 (1895). Prof. Wilmon Newell published, in 1899, from Iowa, Contributions from Dept. of Zoology and Entomology, No. 3 [illegible] College, an article upon "The North American Species of the Sub genera *Diaspidiotus* and *Hemiberlesia* of the genus *Aspidiotus*" including Prof. Cockerell's original description of *A. howardi* Ckll. and giving as its habitat Colorado and New Mexico. More recently it has been given position in "Tables for the Identification of Rocky Mountain Coccidae" (scale insects and mealy bugs), published by Prof. Cockerell.

plum trees severely attacked. In the report for 1902 Professor Gillette reported his discovery of it upon the leaves of white ash trees in Denver.

Though the insect has been previously reported in various entomological publications, and notes have been given upon habits and portions of its life history, nothing, up to the present bulletin, has been published upon its control.

In Mesa county the Howard scale was found, by the writer, to be doing much damage. It was found in practically all localities where its food plants were known and at elevations above sea level varying from something over 4,000 feet to nearly 7,000 feet. Dr. S. M. Bradbury, horticultural inspector for Mesa county, reports that what he has taken to be Howard Scale has been known in the Grand Valley as a pest upon pears and other fruits since they were first grown here. In many instances fruit growers observing the infestation of their trees by a scale insect had suspected the presence of San Jose scale, while others supposed it to be the Putnam scale common in other states upon certain shade and fruit trees.

The fruit growers and fruit growers' associations of the Grand valley have given hearty co-operation in offering their orchards and materials for experimentation and otherwise aiding in bringing new data to light. Also acknowledgements are due members of the Bureau of Entomology at Washington for cuts furnished and determinations made; to Miss Miriam A. Palmer, entomological artist, of the Experiment Station for original drawings of the insect, and to Professor Gillette for valuable suggestions and much special assistance given.

FOOD PLANTS.

Notwithstanding the occurrence of this insect upon shade as well as fruit trees it is primarily an economic pest of the latter. In my observations it has been taken upon the following fruit trees: pear, prune, plum, almond, apple and peach. By far the greatest injury has been done to pear and by many orchardists it is popularly called the "pear scale."

Bartlett pears seem to be most commonly infested of varieties grown in Colorado. Certain varieties of fruit will often become heavily infested and require spraying long before sorts more nearly immune show any noticeable number of the scales.

Next to the pear, the prunes and plums seem to be the most susceptible. It seems that Wild Goose and other varieties of American plums show infestation more generally than the Japanese varieties. Silver prune trees are often found encrusted. Almonds, though grown to a limited extent in Western Colorado, seem to be quite susceptible to its ravages.

It is rather the exception than the rule to find apples attacked. A singular preference is shown, however, for the Grimes Golden. Scores of instances have been noted where trees of this variety show infestation and other varieties growing near by are totally exempt.

Slight infestation has also been found upon Bailey Sweet, White Winter Pippin, Snow and Jeneton.

Peach trees are practically exempt, probably only becoming slightly infested when standing very close to other varieties which are more commonly attacked. This is of rare occurrence, peaches and most varieties of apples being practically uninjured by the insect—a singular fact in consideration that the San Jose scale is most destructive to peaches and apples. Numerous cases are known of its existence upon native plum trees growing in the state. Of the shade trees reported infested, we have the white ash and the maple, the latter reported by Professor Cockerell.

From its appearance only in the two states named it seems probable that it originally lived upon native trees or plants and found suitable food upon the fruit trees planted adjacent to them in recent years.

NATURE OF DAMAGE.

Injuries from this insect are seen in the dwarfing of the trees robbed of their sap, cracking the bark, killing the tree outright, and in an unsightly pitting of the surface of the fruit with discoloration about the points of scale attachment. Upon the greener portion of the pears, the side shaded during growth, this reddening is more noticeable than upon the sun-exposed side. Some of the pits or indentures contain single scales and some bear clusters of several. In the case of yellow-skinned plums these reddened blotches about the scale are most noticeable and objectionable. With dark colored plums, prunes and pears, the scales appear as many small white specks scattered over the surface (plate I, fig. V). With the pear, deep pits are also found in the skin, with Bartletts some of these measure nearly one-fourth inch deep and as wide across at the top. (See plate I, figs. V. and VI). More often the scales are grouped into clusters about the calyx or stem end of the fruit. All fruit so injured is excluded from the fancy grades and placed in the cheaper ones if not rejected entirely.

Early descriptions of the insect gave it as a pest principally upon the fruit instead of the tree. The tendency to infest the fruit is perhaps greater than with other closely related scale insects, but the attack is also directed to bark, twigs and leaves. A marked tendency is shown for the insects to crowd outward to the tips of the branches where the bark is more easily pierced by them or where more succulent and tender tissue such as leaves or fruit is available.

When the twigs become heavily infested with the scales they may almost hide the bark as shown in the prune twig in plate I, fig. IV. If allowed to go unchecked upon trees most susceptible to their attack, the result will be a complete coating over the bark with an incrustation of the bodies of the insects and their scale secretions. Trees allowed to remain in this condition might be completely killed, and would bear only scale-covered fruit and leaves. The fruit would be quite unmarketable and the leaves, browned and impoverished by their sap sucking

parasites, would drop from the trees prematurely. Before spraying became generally adopted in the Grand Valley, the products of whole pear orchards were rendered unmarketable.

DESCRIPTION AND LIFE HISTORY.

This scale belongs to that class of insects receiving their food by sucking the juice of the plant to which they are attached. Having no mouth parts with which to chew their food, stomach poisons or arsenical sprays are without value applied to them. They must be controlled by contact sprays. They are of minute size and many times when but moderately abundant upon trees escape notice except by the trained observer. Every fruit grower should acquaint himself with the appearance of the pest and, if possible, be able to distinguish it from its nearest relatives. This will not always be possible for the average orchardist and it will be advisable to send samples of scale insects found upon the trees to the entomologist of the Agricultural Experiment Station, for determination. This should be done to avoid the mistake of maintaining more dangerous forms of insects which might be introduced by change. The figures of Plate 2 show the insect drawn from life, but enlarged, represent its various stages, details of structure and general appearance and will aid in the determination of the species.

The male is the only form bearing wings and it is winged only upon becoming adult. All females and the males throughout the greater part of the year spend their lives attached and immovable upon the bark, leaves or fruit and it is during this time that the damage to the host plant is done. It is during this period of their lives that the hard, scaly coating forms over them, as a protecting covering. The scales are secretions from the body of the insect concealed beneath. A short period is spent by both sexes crawling over the surface of the tree or its fruit before settling down for feeding. This period of but a few days duration at most, follows the hatching of the young from eggs deposited beneath the scales. At this time the very minute insects are scattered over the infested bark, appearing to the naked eye as mere specks of yellow orange dust. They are much smaller than newly born young San Jose scale. For so small an insect they are very active. One under observation traversed a distance of one-half inch in one minute. When it finally settles down it inserts its beak through the epidermis of the plant and, if a female, from that time to its death does not move. If a male, it remains stationary through its development to the adult and then equipped with wings, comes out from beneath its covering for the fertilization of the full grown females still beneath their scales.

When first attaching itself to the bark the secretion of the scaly covering commences. The newly settled individuals appear as very small white specks, as at that time the white fibers of the secretion have not yet become matted together nor assumed the darker hues. The female scale in developing assumes a circular outline and lies slightly convex upon the surface. Individually when matured, it is of a pale

grayish color, much lighter than the partially matured or even fully grown female of San Jose scale. The female insect when fully grown is, in diameter, considerably less than the head of a common pin. She is orange yellow in color, and broadly pyriform or pear shaped. It is only through a higher power of the microscope that the characteristic markings at the tip of the abdomen (Plate 2, figs. I and II), distinguishing this insect from each close relative as the Putnam or San Jose scale, can be observed. The male scale are more elongate than the female scales, being oval in outline and often much darker in color. The male insects when fully grown and emerged are winged, of very minute size and pale yellowish brown in color with black eyes which show plainly in the developing pupa while still beneath the scale.

The chief difference in the general appearance of Howard scale from its near relatives is in the distinct pallidness or tawny of the scales.

Badly infested trees have a grayish appearance over their bark such as if a layer of ashes covered the tree. When rubbed, this gives the surface a greasy or buttery appearance caused by the crushing of the bodies or exuviæ of the yellowish pupæ and adults which had been secreted beneath their grayish armor. Orchardists should be able to detect their presence long before the infestation has reached this stage. At first appearance, individual scales upon the bark will exhibit only inconspicuous grayish dots. If upon the branches of the apple, these dots will be surrounded by reddened areas in the bark, which will be noticed before the insect is seen. If upon the twigs of fruit trees other than apple these reddened blotches in the bark will be less noticeable.

The winter is spent as immature insects. On March 19, in the spring of 1906, some female scales were found well grown and pale gray to dark brown in color. Others among these were smaller in size, some circular and some oval in outline. All smaller sized scales near their centers showed a whitish area, in some cases dusky gray. In the center of the white area which occupied about one third of the surface of the scale covering, a small whitish nipple was seen surrounded by a rather shallow or indistinct furrow or ring. Both ring and nipple were much less conspicuous than in the case of San Jose scale at this stage. On account of the weathering, most of them showed their summits as smooth or bald areas, reddish or orange in color. The oval male scales were found to yield adults as early as April

*The original description of the insect as published by Prof. Cockerell in Can. Ent. XXVII p. 16, 1895, is as follows:

Aspidiotus howardi n. sp.—Female scale, circular, flat, about 1½ mm. diam., pale grayish with a slight reddish tinge; exuviæ sublateral, covered, dull orange secretion over exuvie easily rubbed off.

Female broadly pyriform, orange; margin of terminal portion thickened, very finely striate-showing a violet color in some lights. Plate spinelike, sparingly branched. Median lobes very large and prominent, close together but not contiguous, obliquely truncate, slightly crenate. Second pair of lobes small, broad and low. Third pair practically obsolete. There are conspicuous wax ducts. See Plate 2, Fig. 1a.

3 in the orchard, at which time several winged specimens were seen in process of fertilizing the matured females. Examination of infested trees at Grand Junction, February 9, 1907, showed the male larvae beneath the scales already with their black eyes apparent. No pupae were yet formed. Material taken indoors upon twigs has yielded males as early as February 22. The males seemingly emerge throughout the greater part of the summer.

Early in June many newly hatched insects of both sexes were beginning to crawl actively over the bark. By June 9 many had settled down, thickly covering the bark with the early summer brood. Some were upon the small pears also and others were seen upon the upper and lower leaf surfaces. Many at this date had well developed scale coverings already secreted over them. Oval eggs, pale yellow and with blunt ends, were found,showing the females to be oviparous rather than viviparous as in the case of the San Jose scale. The exact time required for hatching is evidently short for through the summer are usually to be seen from one to a dozen minute yellowish-orange colored and newly hatched young beneath each of these scale coverings along with small clusters of eggs. In cases, no eggs but only clusters of the very minute young, are to be found beneath the female scales and it has been suggested by Professor Gillette that they are occasionally born living.

In Western Colorado it is probable that at least three and perhaps four generations are developed during the season, including those living through the winter in an immature stage. These generations, however, greatly overlap one another making a continuous succession of individuals appearing throughout the season.

MEANS OF DISTRIBUTION.

The most common method of distribution of scale insects over long distances is well known to result from the shipment of infested nursery stock. Since almost all of the new orchard plantings within the state are of nursery stock from states free from this pest, and as little nursery stock is shipped away at present, this phase of the question does not appear to be of any particular consequence.

The local transmission of the insect is largely dependent upon outside forces as the only time during which the female has power of locomotion is for the short period from its hatching beneath the scale covering to the time it settles down to feed at a fixed point upon the plant. This interval of activity is, however, of short duration and no great distance can be traversed in the time by so small an insect. Except for dispersal over single trees the insect must depend upon outside agencies in spreading. Such agencies are the wind, other crawling and flying insects upon the trees, as ants and lady beetles, birds and chickens or live stock at large in orchards. Irrigation ditches evidently transport the minute active individuals which have been blown or washed from infested trees. It is also likely that the common operations of the orchard, such as cultivation,

PLATE I

pruning and picking of fruit serve, to some extent, to carry the movable ones from one tree to another.

The effect of an infested orchard in infesting surrounding orchards is one of the most serious phases of the problem. On account of this scale spreading so slowly, it is noteworthy that well directed efforts of control are likely to be followed by quicker and more lasting results than when orchardists wage warfare against more active insects.

FIGURE 1

Howard scale parasite, *Prospalta aurantii* How., greatly enlarged. After L. O. Howard, Bur. of Ent., Washington, D. C.

NATURAL ENEMIES.

In a count made upon badly infested pear trees March 19, 1906, of a large number of scales, about 31 per cent contained no living insect. This did not, however, correctly represent the natural mortality of the insects due to weathering. Some of the dead scales resulted from parasitic or predatory insects.

Early in June and again in the month of August adults of an interesting little bee parasite were observed. Specimens were determined as *Prospalta aurantii* How., and the observation according to Dr. L. O. Howard is the first record of the parasite infesting this insect. The minute bee develops within the body of the insect and eats a small round hole through the scale where it makes its escape. Dr. Howard reports that this parasitic bee has been reared from San Jose scale and is effective against nine other species of scale insects common in different parts of the United States. A cut of the adult parasite is shown, greatly enlarged, in Fig. 1.

Adult and larvae of a common lady beetle, *Chilocorus bivulnerus,* also played some part in the destruction of the scale. The beetles winter as adults and have been seen as early as February crawling over the bark performing their useful work. Adults of the beetle have shiny black outer wings each bearing a beautiful spot of red. The beetle in its various stages is shown in Fig 2.

Last summer small spiders were observed destroying the newly hatched scale insects upon infested pear trees. Webs spun across the

PLATE II

calyx end of pears were found filled with the wings and remains of male scale insects which had been entrapped and destroyed. Unprotected female insects were also found to have formed a portion of the spider's food, though those protected by scales were apparently unmolested.

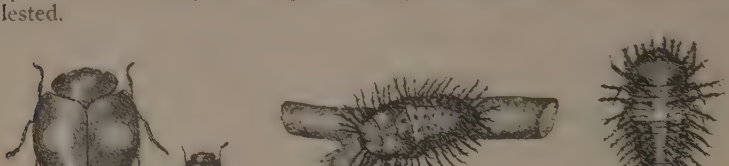

FIGURE 2

Twice stabbed lady beetle, *Chilocorus bivulnerus*, larva, pupa and adult natural size. After Bureau of Entomology, Washington, D. C.

Natural enemies, though very useful, do not usually succeed in reducing this pest to a degree making spraying unnecessary.

REMEDIES.

Experiments in Mesa County.—The first spraying against this insect in Mesa county, according to the statements of local fruit growers, was about six years ago when the finding of "scaly" fruit called the attention of the growers to the necessity of steps toward control. The first material used seems to have been sprays of whale oil soap. These sprays, though expensive and inconvenient, proved fairly efficient in the hands of growers thorough in their methods and careful in preparing the mixture. At the time of the writer's first examination of pear orchards in the Grand Valley many were found which had been most successfully treated with the lime-sulfur-salt spray. Great variety of opinion existed regarding the method of preparation, the proper formulas and the best way and time in which to apply the spray. Sufficient difference of opinion existed to make spraying experiments advisable.

Accordingly the pear orchard of Mr. Ray D. Garrison, east of Grand Junction, well suited to the experiment was selected and given treatment with the permission and co-operation of the owner.

The orchard consisted of about 200 medium sized trees, of Bartlett, Clapp's Favorite, P. de Esta, Buerre de Anjou and Flemish Beauty varieties, the last being largely left untreated the previous year and now thickly covered by the scale. The spraying was done April 3, 5 and 6, 1906, just before the opening of the fruit buds, and a thorough coating was given to all parts of the tree. Upon all plats spraying was done with the same degree of thoroughness. The insecticides used were variations of the lime and sulfur washes, kerosene-lime emulsion prepared by combining kerosene with lime, and scalecide.

Scalecide is an oil treated chemically so that it may be mixed with cold water without separation. It is a commercial product and is sim-

ple to prepare for spraying. It requires no special manipulation and is pleasant to apply. Scalecide was sprayed upon trees in another orchard and gave most promising results. The kerosene-lime emulsion proved a failure, as too great difficulty was encountered in mixing the materials.

The lime and sulfur sprays were, from all standpoints, most satisfactory. They were used in the experiment as follows:

(1) Rex lime and sulfur, diluted 1 to 11 with cold water.

(2) Rex lime and sulful, diluted 1 to 8 with cold water and 15 pounds lime added per 50 gallons spray.

(3) Lime-sulfur-soda wash prepared without use of external heat and boiled by the soda and heat of the slaking lime. Thirty pounds lump lime, 15 pounds sulfur and 5 pounds caustic soda per 50 gallons water were used.

(4) Lime-sulfur wash prepared in the usual way by boiling 45 minutes with external heat and composed of 15 pounds lime, 15 pounds sulfur per 50 gallons water.

A portion of the trees were left unsprayed for comparison. Before spraying, counts were made which showed 69 per cent of the lice living and 31 per cent dead from natural causes.

These comparisons for all plats are shown in the following table:

LIME-SULFUR WASHES AGAINST HOWARD SCALE ON PEAR.

Spray	Formula	Cost per 200 gallons spray	Date Spray'd	Scales on bark Apr. 25 Per cent dead	Scales on pears Aug. 17 Per cent pears pit'd
Commercial Rex Lime-Sulfur	Rex, 1 gallon Water, 11 gallons	$4.15	3-5 Apr.	74.9	−1.0
do.	Rex, 1 gallon Water, 8 gallons Lime, 2¾ pounds	$5.70	6 Apr.	85.2	2.8
Self-boiled Lime-sulfur soda	Lime, 30 pounds Sulfur, 15 " Caustic Soda, 5 lb Water, 50 gallons	$3.45	6 Apr.	95.6	1.0
Lime-sulfur Boiled	Lime, 15 pounds Sulfur, 15 pounds Water, 50 gallons Boiled 45 min.	$2.00	5 Apr.	93.8	0.6
Check	Not Sprayed			48.0	96.1

The above spraying observations were made upon both treated and check trees throughout the season. Two means of comparison

their surfaces.

COMMERCIAL REX MIXTURE.

[illegible] Neb. [illegible] spraying [illegible] be added if [illegible] left until [illegible] covered, and to [illegible] of the mixture [illegible] a clear liquid.

[illegible] both strengths [illegible] the trees so that [illegible] in their effectiveness [illegible] these two results are [illegible] for market [illegible] unsprayed, [illegible] scales of varying sizes. [illegible] 25, twenty days after [illegible] dilution, and 74.9 [illegible] the lesser mixture. The [illegible] determined for a considerable time [illegible] figures represent the increased effectiveness [illegible] and the addition of milk of lime. [illegible] comparison with the 48 per cent [illegible] remembered, 31 per cent of the scales [illegible] the beginning of the experiment and [illegible] counted upon April 25 on sprayed plats [illegible] dead from natural causes without [illegible] given, therefore, under estimate the ratio of benefit actually derived from the sprays.

[illegible] be said that Rex lime-sulphur diluted one to eight [illegible] lime added as per formula is an effective spray against the Howard scale. It is not recommended as more effective than the standard orchard boiled lime and sulphur washes. As was shown by experiment, the latter were slightly more effective than the Rex when used at the stronger strength, but the ease and convenience of preparation of the Rex recommends it to the use of orchardists not fitted with the appliances for boiling their own spray. Some growers prefer to pay more for material and save the time and labor of preparing their own mixture. Examination of the scales shows them more loosely attached to the bark than is the San Jose scale, thus affording less resistance to the spray in coming in contact with the body of the insect.

In the spring of 1906, in the orchard section of the Grand valley, a carload of 30,000 pounds of Rex was used experimentally as a spray principally against this insect, and in the spring of 1907 five car loads were shipped into the above section for use against this and other orchard pests. Upon Howard scale results have been satisfactory.

The spray has the disadvantage, as a commercial product, of being subject to variation in strength without knowledge of the consumer. The orchardist compounding his own spray material may feel more confident of his product.

The Rex mixture was to be had the past season by growers at Grand Junction for 25 cents per gallon, making the cost of 200 gallons of spray of the recommended formula about $5.70, or a trifle less than 3 cents per gallon.

Lime and Sulfur Mixtures. The lime and sulfur wash mixed in the right proportions, properly boiled and correctly sprayed is the most satisfactory spray thus far used against Howard scale.

Lime and sulfur was originally a stock dip used in California and was first demonstrated to be of value as an insecticide in 1886.* It was then taken up as a scale treatment in the East and is now very widely used and considered the standard scale remedy. It is also valuable as a dormant tree spray against many other insects and is of known fungicidal value, controlling the peach leaf curl of some states.

Different formulas have been adopted in different states. Some recommend slightly more lime than sulfur in order to insure the combining of all sulfur. Others contend that equal parts of lime and sulfur are best when a strong quick lime, high in calcium, is used. The belief that equal portions of lime and sulfur, as a rule, produce as strong a solution, chemically, as is possible to secure, is endorsed in a recent bulletin by J. R. Haywood of the Bureau of Chemistry.* The addition of salt formerly recommended may be safely discontinued. It adds nothing to the killing effect of the spray, increases cost, makes the spray more unpleasant to use and harder upon machinery. The addition of copper sulphate (blue vitriol) to the formula has been recommended by some experiment stations, by others it is considered without insecticidal value,* and by some it is regarded as a positive injury to the insecticide properties of the spray.*

Variety of practice in the preparation of the spray is to be found. All methods provide for chemical union between lime and sulfur brought about by heating with water. The heat may be supplied in a variety of ways externally and the spray has been made by heating with caustic soda, potassium sulfide or an increased amount of quick lime.

The so-called self-boiled lime-sulfur-soda wash used in the experi-

* Bulletin No. 166, Calif. Agr. Exp. Sta., 1905.
* Bulletin No. 101, Bur. of Chem. U. S. Dept. of Agr., Feb., 1907.
* Ill. Agr. Exp. Sta. Bulletin No. 107, 1906.
* Wash. Agr. Exp. Sta. Bulletin No. 76, 1906.

ment referred to is a common formula where both quick lime and caustic soda produce the heat of the mixture.* Another formula sometimes used by growers provides for an excess of quick lime to produce the boiling heat. Others use this method except that hot water is required to quicken the slaking process. The formula using caustic soda, probably the best of the above self-boiled mixtures, though saving cost of boiling by fire, increases the cost of the mixture. At average local prices at the point where the experiment was conducted, the cost of the mixture was $3.45 per 200 gallons as compared with $2 per 200 gallons for the standard orchard-boiled wash.

It has seemed to the writer that attempts at preparing the mixtures without the aid of external heat has usually resulted in leaving a portion of the sulfur uncombined. This is indicated by the yellow color of the mixtures so prepared. A wide difference in the color of the sediment was noted in the mixtures prepared by different methods in the experiment. The ratio of sediment to liquid also showed wide differences. The strength of the lime-sulfur wash will depend upon the strength of the soluble portions and upon the sediment. The sediment is supposed to gradually decompose into nascent sulfur, which remains upon the tree and continues destructive to insect life for a considerable time. An excess of coarse sediment in the spray is a disadvantage in that it clogs the nozzles and increases the wear on the pump.

Lime-sulfur washes were originally boiled by fire two hours or more. Later observations show that less time is sufficient. About forty-five minutes will generally form as effective a spray as can be secured, though the proper time required for boiling must be indicated by the changing of the undiluted mixture in the boiling vessel from a yellowish to a dark amber color. A properly boiled mixture, after diluting for spraying, will be of a reddish orange color and have a greenish sediment. The lime and sulfur should be boiled in about one-fifth the total amount of water and then diluted with either hot or cold water to make desired quantity of spray. Undiluted material should not be allowed to remain over night in the boiling vessel, for it will harden. Standard lime-sulfur mixture is intended for immediate use. So caustic is the spray that the hands of one using it should be protected by gloves. Apparatus should be rinsed with water each time after using.

Directions for Preparing Standard Lime-Sulfur Wash. The following formula and brief description for preparation of a small amount of the standard lime-sulfur wash is recommended for Howard scale.

Formula.

Quick or lump lime	15 pounds
Flour or flowers of sulfur	15 pounds
Water	50 gallons

To prepare fifty gallons of spray place seven to ten gallons of

*N. Y. Agr. Exp. Sta. Geneva, Bulletin No. 247.

water in the boiling vessel. While the water is being heated by a hot fire, mix in a separate vessel fifteen pounds sulfur with enough water to form a thin paste. Add this sulfur paste to the water and bring the mixture to a temperature just below the boiling point. Now add fifteen pounds good lump lime. A violent slaking will at once take place. Keep cold water at hand, adding if necessary to prevent boiling over the sides of the vessel or to keep the mixture from becoming too thick. After the lime has ceased slaking, keep steadily boiling for forty-five minutes, stirring almost constantly, when it will be ready for dilution with hot or cold water to make up fifty gallons of spray. It is then ready to be strained and applied.

Time to Spray. Late spring will be the best time to spray for this insect, though a fall application, after the leaves are off, will be effective. It should always be borne in mind that the lime-sulfur wash is a caustic spray designed only for dormant trees and not to be sprayed upon trees in foliage. Late spring is preferable to early spring sprayings. It should not be delayed too late lest there be danger of injuring the tender fruit buds. Pear buds, though swollen may, ordinarily be sprayed with safety even when the minute green leaves are showing beyond the tips of the bud scales. After the green leaf rudiments are in view a cluster of rudimentary pears, each borne by separate pedicel or stalk, will be found within each swollen bud. One may probably spray with the mixture up to the time these bloom stalks separate into distinct buds, just before unfurling their first petals.

Orchardists should begin their spring spraying for this pest in ample time so that it may be completed before it is too late. The time allotted will depend upon local conditions such as size and number of trees, and kind of apparatus.

Application. Success in spraying against this insect, as with others, depends more upon the thoroughness with which the spraying is done than upon any other detail. All portions of the tree, from the tip of the twigs to the base of the trunk must be completely coated. Trees must be sprayed from all directions. Strong winds at time of spraying will sometimes make this a difficult undertaking. The tips of twigs around the outside of the tree and in the top should not be neglected. Fortunately the spray is of such a color that parts of the bark left uncovered may be readily detected. If such spots can be found, the spraying there should be repeated.

Apparatus. Kind of apparatus used in preparing the wash will depend largely upon the amount to be used.

Prepared in a small way, iron kettles are found suitable, such as are shown in plate I. fig. II. For small amounts a very convenient and inexpensive boiling vat is made with No. 18 sheet iron bottom with fourteen-inch planks for sides. The ends of the tank are formed by bending upward the two ends of the iron bottom, without forming sharp angles. The outside dimensions are 6 ft. by 2 ft. 6 in. Before nailing on the iron bottom to the edges of the plank, insert a strip of felt between wood and iron and coat with a heavy lead paint. Nail

on the sheet iron tightly and cement the joint upon brick sidewalls. A low brick chimney is constructed at the rear connecting with the fire box beneath the vat. Such a vat is large enough to prepare 200 gallons of spray or more at once. There are many of these vats used about Grand Junction.

Boiling [illegible] with steam is by far the best method. Portable steam engines, such as are used for running small flour mills, are suited admirably to the purpose. Some spray machinery manufacturers have boilers on the market well adapted for this work. With them the boiling can be done economically. A steam pipe or pipes from the boiler is directed into the mixture and the strong jet of steam automatically stirs the liquid while the boiling is progressing.

Where large quantities are to be prepared, a steam boiling plant, such as the one shown in plate I, fig. [illegible] will be needed. This plant is built upon most improved and modern ideas and is found indispensable for preparing lime-sulfur wash upon the 240 acres or [illegible] of the [illegible] at Hesperus. A large steam engine beneath supplies the steam, which is conducted in pipes into the boiling barrels. The latter are arranged in a row upon an elevated platform, at the end of the boiling vat at a higher level so the water may be filled by gravity and supplying the water for boiling and [illegible]. The small building at the rear is built for a storage warehouse. The vats [illegible] capacity of 400 gallons [illegible] and the boiling barrels [illegible] by gravity directly into the spray vats. The [illegible] and spray tank in process of being filled.

The material may be emptied by small spray pumps or larger spray outfits. A large number of [illegible] are in use [illegible] long spray poles and long lengths of hose are [illegible] nozzles of larger apertures than those used [illegible] are available.

A well appointed [illegible] will provide means for ease and convenience of [illegible] against the [illegible]. This is important since lime sulfur spraying has become an essential part in the routine of orchard work.

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Aspidiotus howardi Ckll., Taylor, Press Bull. 30 Colo. Agr. Exp. Sta. (1907)

SUMMARY.

(1) The Howard scale is present in injurious numbers in many fruit orchards of Colorado.

(2) The pest was first discovered in this state and is supposed to have originated upon plants native to the locality.

(3) It is less destructive than the San Jose scale which, so far as is known, is not present in the state.

(4) The insect has been found to infest many varieties of fruits, but is primarily a pest of pear, plum and prune.

(5) Damage may result from the insects attaching themselves to either tree or fruit, where they absorb the sap as parasite. Trees may be killed outright or fruit may be rendered unmarketable from its "scaly" appearance.

(6) The insects when attached to the surface of fruit or tree are of minute size—about the size of a pin head.

(7) By rapid rate of increase they may produce enough individuals to completely encrust the surface of the plant attacked. It is their rate of increase and gregarious habit of life which make them so destructive.

(8) The female insects are wingless throughout their entire lives and except for a short period following hatching are entirely motionless.

(9) The spread of the insect is dependent largely upon agencies outside the control of the insect.

(10) Samples of scale insects found upon fruit trees should be sent to the entomologist of the Agricultural Experiment Station for determination.

(11) Natural parasites and predaceous insects preying upon the pest do much to hold it in check but have not, in the past, increased enough to make other measures unnecessary.

(12) The lime-sulfur wash applied in late spring before the buds open has been found a complete and practical remedy.

KEY TO ILLUSTRATIONS.

Plate I.—I, Plant for steam cooking several barrels of lime-sulfur mixture at once, owned by Mr. John Ashenfelter, Montrose, Colo.; II, cooking lime-sulfur in kettles; III, *Aspidiotus howardi*, (A) scales upon pear twig, (B) dead females' scales of last year, (C) young living female scales, (D) adult male scales, a male emerging at c, all enlarged seven times—drawn by Miriam A. Palmer; IV, photo of dead and living scale upon prune twig, considerably enlarged; V, pear showing large scales in depressions, also young white scales scattered about, somewhat enlarged; VI, pear with scales removed showing pits caused by the lice.

Plate II.—Howard scale, *Aspidiotus howardi* Ckll. I, Pygidium of female showing dorsal characters on the left (A), and ventral characters on the right (B), a, wax ducts; b, oval dorsal glands; c, grouped ventral glands. 190; II, the same, showing variation in the number and form of the glandular hairs or plates; III, newly hatched young. × 95; IV, adult male, × 62. Original drawings by Miss Miriam A. Palmer.

Fig 1.—Howard scale parasite. *Prospalta aurantii* greatly enlarged. After L. O. Howard, Bureau of Entomology, Washington, D. C.

Fig. 2.—Twice stabbed lady-beetle. *Chilocorus bivulnerus*; larva, pupa and adult enlarged and the adult natural size.

Bulletin 121 March 1907

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

ALFALFA, SUGAR BEETS, CANTALOUPES

NOTES 1906

BY

P. K. BLINN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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ALFALFA, SUGAR BEETS, CANTALOUPES

NOTES, 1906

By P. K. BLINN

ALFALFA

Improvement by Seed Selection—The alfalfa seed nursery established in 1905 for the selection and improvement of alfalfa, was given as uniform conditions as possible as to care and irrigation; yet there appeared a marked contrast in the size and the early development of six rows of Turkestan alfalfa in the center of the plat, as compared with four rows of native alfalfa on each side. The Turkestan alfalfa was up three inches high by April 1st, while the native rows had not begun to show above the ground; many of the Turkestan stools would measure six to eight inches in diameter, while the native stools would hardly measure three to four, as they broke through the surface of the ground. The Turkestan was also characterized by wide clover-like leaves, as compared with the native, though this character varied in individual plants.

Each stool in the plat consisted of one plant, the nursery having been thinned to one individual to a place; the rows were 20 inches apart and the plants about the same distance in the rows. Plate 2 shows the contrast in the plat, April 15, 1906.

Owing to the marked superiority revealed in the Turkestan alfalfa, it seemed advisable to begin the work of seed selection with this variety, and as we had secured a selection of seed from the most promising plants in the native rows the previous season, we accordingly cut out the rows of native alfalfa, and also eliminated all undesirable plants in the Turkestan rows.

Plate 3 is a view of 12 rows of new seeding from the seed above mentioned which was added to the nursery this year. During the season a close study was made of the individual plants to determine their variations desirable for seed selection. In the plat of over four hundred plants, sixteen were selected for their special characteristics.

Seed producing tendency was a prime consideration for obvious reasons, for how to get a good yield of alfalfa seed is an important question in Colorado. The variation in this respect of the individual plants in the plat was very marked and exceedingly promising of valuable results; for the results of tests so far, seem to indicate that these variations can be fixed through seed selection.

The following notes indicate the characteristics of the plants from which the seed was selected; in each case the seed was the

*This Bulletin is the report of progress of Mr. Blinn as Field Agent, for 1906. It was not prepared as a bulletin.

product of a single plant and had been cleaned, labeled and saved separately, and the original plant from which it came has been marked.

PART OF REPORT FROM ARKANSAS VALLEY FIELD AGENT

Plant 1.—Yield of seed, 66 grams; fine stems, thick set with leaves; desirable plant for hay; seed irregular in ripening; bloom, green pods and ripe seed on the plant at the same time.

Plant 2.—Yield of seed, 45 grams; many fine stems; very little rust or disease on the leaves; seed fairly uniform in ripening; a desirable type for hay.

Plant 3.—Yield, 53 grams; many short, thick stems; seed plump and uniform in ripening; style of stems desirable for supporting seed, but not promising for hay.

Plant 4.—Yield, 24 grams; few long, coarse stems; rust common on leaves; undesirable type.

Plant 5.—Yield, 24 grams; few long stems; seed fairly uniform in ripening, but not desirable for hay.

Plant 6.—Yield, 37 grams; stems long and coarse; seed irregular in ripening; undesirable type.

Plant 7.—Yield, 33 grams; long, coarse stems; seed irregular in ripening; undesirable type.

Plant 8.—Yield, 34 grams; seed head short and small; ripening uniform; not desirable for hay.

Plant 9.—Yield, 40 grams; stems fine; seed very uniform in ripening; a desirable type.

Plant 10.—Yield, 25 grams; a small plant; seed ripened uniformly, with no second growth of stems.

Plant 11.—Yield, 30 grams; stems and leaves free from rust or disease; seed uniform in ripening; a desirable type.

Plant 12.—Yield, 54 grams; fine, large plant; large clusters of bloom; large, uniform seed pods; ripening uniformly; a very desirable plant.

Plant 13.—Yield, 43 grams; fine stems; no rust; uniformly ripe; a desirable type.

Plant 14.—Yield, 41 grams; fine stems; small heads of seed; not regular in ripening.

Plant 15.—Yield, 44 grams; fine stems; no rust on leaves; a desirable type.

Plant 16.—Yield, 55 grams; many fine stems; leaves well retained; seed ripening fairly uniform, while the stems still remained green; very desirable type.

Plant 17.—Yield, 49 grams; seed from a native stool that grew on dry land with no irrigation; had remarkably large flowers that set uniform, with seed that ripened uniformly and was almost perfect in color and plumpness; stems desirable for hay; seed pods on adjacent plants under the same conditions blasted and failed to make seed.

The seed of some of the above plants was selected not for their desirable traits, but to test their future behavior and their reproducing power, and to determine the most potent tendency of the several types.

The average of those that were good seed yielders would amount to over one and a half ounces of clean seed to the plant; this computed for a theoretical yield to the acre, allowing four square feet to the plant, would give one thousand pounds per acre—a yield that does not seem impossible, and one that would be profitable even on highly valued land.

The following, Plate 4, is a view of two adjacent plants as they stood in the nursery row; the one to the left is plant No. 12.

The color contrast of the seed pods was not enough to show

1. A Characteristic Plant of Turkestan Alfalfa.
2. Turkestan Alfalfa Rows Bordered by Common Alfalfa, taken April 15th.
3. Alfalfa Nursery.
4. Two Alfalfa Plants.

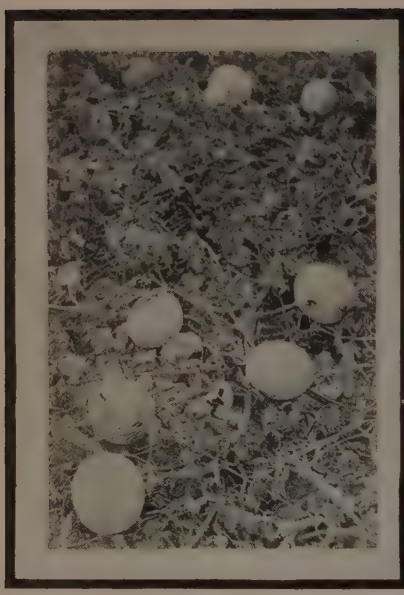

PLATE V.
A Vine Rusted on Check Row.

PLATE VI.
Adjacent Vine Showing Resistance to Rust.

PLATE VII.
Cantaloupe Showing Perfect Netting and Internal Qualities.

the wonderful set of seed as it really was as compared with the plant to the right in the photograph. Both plants had developed under equal conditions in every way, and seemed equally vigorous; both bloomed freely, but while one set seed seemingly at every flower, the other would bloom and blast, which was also the case of the majority of the seeds in the plat; while a few such plants as Nos. 1, 3, 17 and 16 had nearly as much or more seed as No. 12.

Seed Production—In order to determine the conditions most favorable for the production of alfalfa seed, we have instituted a line of personal interviews with some of the most successful alfalfa seed growers, to ascertain their theories and methods regarding the problem; and from such data, together with results of co-operative tests and from our plat work, we hope to determine some of the factors that influence a yield of alfalfa seed, and thus enable the farmer to secure more profitable returns.

The importance of alfalfa in its relation to crop rotation for maintaining fertility is each year more apparent, as the yield from land continually taxed with beets or other crops is contrasted with the same crops grown on alfalfa sod. The breaking up of the old alfalfa fields and the seeding down of the worn out land each year, is creating a demand for alfalfa seed that bids fair to exceed the present rate of supply; for some reasons the present yield of alfalfa seed, even in the best producing sections, is not as good as in former years; and consequently there has been a steady advance in the price of alfalfa seed; this fact and the somewhat uncertainty of success in re-establishing a stand of alfalfa seems to deter many farmers from adopting a crop rotation that good judgment would seem to suggest that they should.

It is in view of increasing the yield of alfalfa seed and solving some of the difficulties of alfalfa growing, that we have undertaken this line of investigation.

BEETS

Under this topic we have continued efforts to develop a disease resisting beet. We have now about 50 pounds of seed produced from the second generation of mother beets since the selection of seed beets from the "curly top" affected fields of 1903. Since that year the trouble has not appeared in Colorado, and in order to test the merits of our selection at this time, we have sent to Dr. C. O. Townsend of the Department of Agriculture, about 25 pounds of this seed; he agreeing to send it out to portions of California and Utah, where the trouble occurs to some extent each year, and will report to us if the seed possesses any inherent resisiting qualities.

In this connection we have gained considerable information relative to the problem of beet seed growing, the methods and conditions necessary for securing a yield of beet seed. Some of the points that have grown out of our experience in this line might be summarized as follows:

1. In a general selection of mother beets for growing seed, there is a wide variation in the seed producing tendency of individuals, and by selecting along this line, our tests have demonstrated that the seed yield can be materially increased.

2. So far, in the beet-growing tests there has usually been a large number of beets that would not grow a seed stalk, but only make a vegetating growth of leaves and root; this feature has varied somewhat with seasons, but our tests have indicated that the soil conditions and the manner of setting out the beets are very essential to uniform seed production.

3. Our method of siloing mother beets has been to silo late in the season, selecting only well matured beets of good shape and size, removing the leaves without injury to the center or crown buds, then layer the beets in dry soil in deep, narrow pits, to protect from frost. Ventilation is necessary, also protection from snows and rain finding their way into the silo.

4. Mother beets should be set out early in April, in this section, selecting a fertile soil, well drained, so that moisture conditions may be controlled.

5. To insure uniform conditions in setting out the beets, a deep furrow should be thrown out and still loosening the soil in the bottom of the furrow, the beets may then be set in the furrows with the crown about level with the surface of the ground; the soil may then be thrown to the beets with a small plow or cultivator, then a small stream of water is run on each side of the row which settles the soil around each beet uniformly. After the beets have started, any soil that may cover the crown is carefully removed; frequent cultivation and irrigation are then applied to induce a rapid growth until the seed stalk appears, then less water is necessary, until the seed begins to ripen, when the water should be withheld.

6. After the seed stalks are well developed, hilling up the rows with soil will prevent much breakage by wind or heavy loads of seed; tying the stalks together with twine is also sometimes necessary.

7. The injury from the false chinch bug is less frequent on alfalfa and grain land that has been kept clean from weeds upon which insects thrive. Thus far, mother beets on clean land surrounded by grain of some kind, have not been attacked by the insect. A flock of young chickens or turkeys has proven a protection from grasshoppers when they are cooped on or near the plat of mother beets.

CANTALOUPES

The question of maintaining or improving the quality of the Rocky Ford cantaloupes becomes more pertinent each year, as we hear the unsatisfactory reports of the irregular quality of the product in all the various markets. The many inquiries and requests for seed from the farmers and the experiment stations throughout the melon growing sections of the United States is

evidence of the urgent needs, and the manifest interest in our work of developing a disease resisting cantaloupe. In order to test the merits of our rust resisting selection under various conditions, we have furnished a few seed to all inquirers from various parts of the United States to those who were willing to make the test in a co-operative way.

As our work of selection was only well begun, we could only furnish what might be termed a second grade selection of seed, as the few seed of the first selection was reserved for our own work. The following are brief extracts from the reports that have been received so far at this time:

"The rust-resistant plat furnished fine melons after the other plats were all dead with rust."—E. C. Green, Texas Experiment Station.

"The melon seed received from you this spring, gave the best melons I have had in previous seasons."—J. D. Fraser, Leamington, Ontario.

"I found the Pollock, or rust-resistant melon superior in quality to the others, but many of them grew rather large."—Chas. L. Goodrich, Glendale, Maryland.

"The reports of three growers who tried the seed you sent me, show that this melon was unusually free from rust, although other melons in the immediate vicinity were badly injured by it."—Samuel B. Green, Minnesota Experiment Station, St. Anthony's Park.

"Until about a week ago the vines showed little or no rust, but at the present writing the leaves are badly spotted; the fruit is good size, and the vines may withstand the attacks until after the melons ripen; I think I gave the variety a very severe test, as the seed were planted on soil that a year ago was devoted to the same crop, which was entirely wiped out by the rust."—H. D. Haskins, Hatch Experiment Station, Amherst, Mass.

"The vines from the disease-resistant seed which you sent me, certainly did resist diseases much better than the old Netted Gem."—F. L. Stevens, North Carolina Experiment Station, Raleigh, N. C.

"I ran all other melons out of the hotels with the rust-resistant "Pollock" seed I got from you."—A. Van Wagenen, Sioux City, Iowa.

From twenty-nine reports from growers in New Jersey, who tested the rust-resisting seed that we furnished Byron D. Halsted of the New Jersey Experiment Station, eighteen reported very favorable results; eight reported that they observed no difference, and three made unfavorable reports; the seed furnished for this test was pure "Pollock" strain, which only had had one year's selection for the rust-resistant feature.

The popularity of the cantaloupe as a fruit on the American table does not seem to diminish, nor does the output or the returns to the grower seem to decrease; these facts are unquestionably due to the greater attention being paid to the quality of the seed selected for planting and also the improved refrigerating and marketing facilities. About the only progress the melon growers have made in regard to seed selection, is the almost unanimous selection and use of single strains of seed by the various associations, thus insuring uniformity. In general, they have selected the strains that were early, prolific, uniform, and also desirable in appearance, with little or no attention being paid to disease-resisting tendencies; in fact, some prejudice exists against the rust-resisting strain, as it is thought to be later and less productive than the strains in general use. This apparent lateness of the rust-resistant strain is probably due to abnormal ripening of the other strains, rather than to any inherent lateness in the rust-resistant strain.

The past season proved very favorable for the development of the rust trouble, and the melon fields went down nearly three weeks earlier than usual; our rust-resistant selection remained green until the majority of the fields were dead, and some of the most markedly resistant plants in the plat remained green until frost, this in spite of the fact that the seed was grown on soil that for four consecutive years had been badly infested with rust, the idea being to develop the quality under as adverse conditions as possible, consequently, irrigation was applied in excess to favor the development of the rust. The plat was planted with the seed of nine individual melons, which had passed the rigid test of selection on the same plat the previous season; one row was planted as a "check" row; seed from a very perfect melon, but from a field that had not been selected for rust resistance. The plat developed nicely until about August 15. The season was characterized by frequent showers and heavy dews, and in July the rust spots appeared on all the early melon fields, and when the first picking began, about August 10th, the fields were getting brown with rust, as was also the check row in our plat, while the other rows were comparatively free from rust. The following photographic record represents the relative condition of the vines on the check row and adjacent rust-resisting row on August 20th; the whole plat having received the same treatment in every respect.

When the rust had developed to some extent on the plat (which began at least ten days later than any other plat under equal conditions), the plat was carefully studied, and over one hundred resistant plants were staked and numbered, and each day as the ripe melons were gathered, these were marked with the number of the hill and the seed saved separately and the description made of the qualities of each. At the close of the season, the plat was gone over and notes taken of the rusted condition of the various plants; this revealed the fact that a few of the whole number, had remained resistant later than others. With the system of numbering used, this seed can be identified and used in further developing this important quality.

Careful consideration and a great deal of time has been devoted to selecting melons with a view to improving their keeping qualities, as well as flavor and other qualities desired in a perfect melon. The following photograph reveals some desirable internal and external qualities shown in some of the melons of our selection.

In order to develop early maturity in our rust-resistant strain, we have made arrangements for a co-operative test, by having some of this seed grown in Canada, the product of which will be tested this coming year at Rocky Ford, to indicate the influence of latitude on early maturity.

Some investigational work in regard to the life history of the melon louse, and the means of combatting it was taken up in co-operation with and under the direction of Prof. C. P. Gillette.

Bulletin 122 April, 1907

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

FRUIT GROWERS' ASSOCIATIONS

BY

W. PADDOCK

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1907

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FRUIT GROWERS' ASSOCIATIONS

W. PADDOCK

The Western Slope District—The geographical location of Colorado, particularly of the fruit district on the Western Slope, is such that it is necessary for the majority of fruit growers to sell their products through associations. This is especially true since the product of her orchards has become so great that the bulk of the fruit must be sold outside of the State. Here we must compete for the markets, usually at a disadvantage because of high, and many times unjust, transportation rates. Car load lots then must be the unit of shipment, but what is more important, the shipper must know the condition of the markets each day in order to place his produce to the best advantage. It must be apparent that the marketing of fruit requires a high type of business ability, and the average grower has small chance in the markets under these conditions. This was particularly true a few years ago before the associations had become important factors in marketing. Since their advent prices have been much more stable, and the entire section has been benefited thereby. Formerly the grower had no means of becoming acquainted with the condition of the outside market, so he was more or less at the mercy of the buyer.

There is a wide difference between the prices received by the producers of farm products and those which the consumers are compelled to pay. Could the two classes deal directly with each other, the law of supply and demand would control prices and each class would be greatly benefited. However, we can scarcely hope to reach this consummation, but much may be done to better present conditions if the farmers can only grasp their opportunities.

Fruit growers' associations are not new institutions in Colorado. Perhaps in no state east of the Pacific coast have they been more successful or longer in operation. But there are still many localities in the State which are either not organized, or where the existing associations have not been so successful as is desirable. Then there are localities where special crops, other than fruit, are grown where the growers would be greatly benefited by marketing their produce through associations. An attempt is made in the following pages to describe the workings of the fruit associations with the idea of being helpful to those who may be interested in such organizations.

The growing of fruit itself is an intricate business and is usually all that one man should attempt. If he makes a success of orcharding, the time of the average man will be fully occupied.

Then he can afford neither the time nor money to keep posted on the conditions of the markets every day, or to become acquainted with the many intricacies incident to marketing.

An association, on the other hand, can afford many of these things, because of the volume of business involved. For instance, the manager must have daily telegraphic reports on the condition of the markets; he often has a personal acquaintance with the buyers, and he finds it to his advantage to make occasional trips for the purpose, even to distant states. He can also have a system of diverting cars after they have been sent out of the State and thus avoid a glutted market, or send his fruit where it will sell to better advantage than where it was first planned. The icing of the cars can also be properly looked after. Associations are often the means of getting lower freight rates, because the hauling of several hundred cars is an item worth competing for, and in a number of instances, the managers have been successful in getting rates changed to their advantage. Such rates are, of course, open to all shippers. Buyers often want a number of car loads of a certain variety and are willing to pay a premium if their wants can be supplied, and not infrequently such sales are the means of disposing of large amounts of the inferior varieties or grades. An individual is seldom in a position to take advantage of such opportunities. Associations are successful in maintaining a uniform pack, and by this means they establish a reputation for their goods. Usually the best grades of fruit are sold as a certain brand. The brand, which should be copyrighted, is sufficient guarantee for the quality, or, at least, it must be if the association expects to gain and hold a reputation.

Supplies of various kinds, which are used on fruit farms, may be bought at wholesale, often in car load lots, as indicated on Page 13, which is quite an advantage, especially in such items as spray and box materials. The saving which the association makes to the growers in this way is no small item, as everything is bought at wholesale. The prices to growers are only slightly in excess of actual cost. And then it is advantageous to keep a certain amount of the better class of help from year to year and to furnish them with employment, so a more or less extensive jobbing business may be carried on, as indicated on Page 13. It will be noticed that not only is a large amount of fruit growers' supplies handled, but a wholesale business in other lines may be done, depending upon the demands of the locality.

And, finally, an association can be handled more economically than it is possible for most individuals to market their fruit, unless they depend entirely upon the traveling buyer, or resort to the doubtful expedient of consigning to commission men.

Given a capable manager and a wise board of directors, there

can be but small chance of failure under our conditions. But men who are capable of handling 500 to 1,500 cars of fruit at a good profit are not common, and when one is found, every effort should be made to retain him. One of the first things that should be done for the manager, when a capable one is found, is to give him a salary in proportion to the amount of business done and the responsibility which must be carried. The latter item is certainly important when we consider that he may be responsible for a number of car loads of a very perishable product, which are on the road at once. Then, too much supervision on the part of the board of directors, who usually have small knowledge of the business, only hampers the manager and restricts his personality. If he cannot make a success of the association in his own way, the advice or help of the directors will be of little use. A much better plan is to give the manager a fair chance to work out his own ideas, and then if he fails, try another. But right here is the cause of most of the failures; too much supervision by the directors and unjust criticism and fault finding on the part of the stockholders.

A common source of discontent is the rumor that a neighbor in another association has received a higher price for his produce, or that an outside buyer is offering attractive prices. Unscrupulous firms frequently adopt the latter method of getting consignments only to swindle the grower. If there was not some decided advantage in buying direct from the growers, these firms would not go to the expense of maintaining an agent in the field when just as good or better fruit could be had from the association.

The association idea is no longer an experiment, and when each one does his share to maintain the reputation of the fruit, and the volume of business is sufficient to pay expenses, there is small chance of failure. The history of associations, the country over, shows that petty jealousies and distrust on the part of the members is the common cause of failure. One writer has summed up the subject in the following terse sentences:

"All classes of farmers are constitutionally and proverbially distrustful of other people and of one another. In a fruit association there arise (such is the experience) the most inveterate jealousies. Each man thinks he is furnishing a better grade of fruit than his neighbor, though all share alike in the profits. Each one fears the other will reap some special advantage somehow. In particular, the appointment of managers, superintendents, supervisors of grading, shipping agents, and all other officials of the company, offers a sufficient opportunity for the elaboration of all sorts of neighborhood quarrels. Each man thinks he ought to be manager, and when one man is finally chosen he is usually suspected of all sorts of favoritism. In any case he is apt to be hampered in his business relations by committees, boards of directors, and various kinds of red tape and foolishness. Often he has to consult a committee before taking any important action. * * *

"Another difficulty which arises from the same cause is that subscribers to such an association never want to pay a manager's wages. Two or three dollars a day is considered good pay. Yet such a man is com-

pelled at times to handle thousands of dollars' worth of business. The position is such as, in ordinary business life, would command a salary of five thousand dollars a year or more.' —(Waugh; Fruit Harvesting, Storing, Marketing.)

Growers who are not members may ship through the association on the same terms, but they are usually required to pay more for supplies.

All of the larger concerns require both members and non-members, for whom they ship, to bring all their fruit to the association.

Formerly stockholders were allowed to sell their own fruit by paying the association a small premium. Neither were objections made to members filling orders from near-by towns. But, as these means of disposing of fruit are manifestly unfair to a majority of the association members, they have come to be looked upon with disfavor and in most instances are no longer allowed.

One of the strong points in favor of the association idea, as worked out in Colorado, is the possibility of a fairly uniform pack. This results in better prices, since buyers have the assurance that all associations strive to make their goods as nearly uniform as possible. Then, contrary to the idea often advanced that poor fruit brings as great a price as good, the most rigid grading must be practiced, and the intention is to place each fruit in its proper grade, thus only the best grade sells for the highest price, and, indeed, the grower of inferior fruit is fortunate to dispose of his crop at all.

There are two methods of packing and grading fruit: in one instance, the association does all the packing, the growers delivering the fruit to the packing house just as it is taken from the trees. Here the packers, under the direction of a superintendent, sort the fruit into the various grades, and at the same time pack it into boxes or crates. Should there be any culls, they are returned to the grower and are at his disposal.

Each grower is given a number, which is used to designate his fruit throughout the season. As each box is packed, it is marked with his number and the grade. When the boxes are loaded into the cars, the number of boxes, the varieties and the various grades which belong to any grower are kept account of and duly recorded. In this way the price for each box of fruit in any car is easily determined.

But where there is a very large amount of fruit to be handled it is impossible for the association to do the packing, consequently the growers assume this work. With this arrangement, the association employs an inspector, whose duty it is to inspect each load as it is delivered. This he does by opening the boxes on the side, in the case of apples, when a good estimate of the contents may be made. If the pack is satisfactory, not more than two boxes may be opened. If unsatisfactory, several may be examined, and if all

run under the inspector's standard, the entire load must either be placed in a lower grade or else be repacked.

It will be seen that a great deal depends on the inspector, and that it is a difficult position to fill. Upon him depends the reputation of the association, so he must be entirely free to do the work as he sees fit.

Each man's fruit is kept track of by numbers, as in the former case.

Most of the associations have now adopted the latter system, although nearly all have tried the former. The ideal method is, no doubt, to have all packing done at a central building, but a limit to the amount of fruit which can be handled is soon reached. It is found difficult in practice to keep track of a large number of packers at a central point, and careless work is the result. But when each grower looks after his own packing, he has a wholesome respect for the decision of the inspector. It is very expensive to repack a lot of fruit, and if he is obliged to do this, or else let it be sold as a lower grade, even on a single load, it usually results in greater pains being taken in the future. But with the best of systems, poorly packed fruit will occasionally find its way to market.

The association charges a commission on all sales, usually five per cent., to defray expenses. Then, in case the packing is done by the association, an additional charge is made to cover the cost of the box and packing. Any surplus is, of course, distributed as premiums. Any fruit grower may become a member of the association so long as there is stock for sale, and the owner of one share is entitled to all of its privileges. The number of shares one individual may own is limited.

The growers are generally asked and, in many instances, required to furnish an estimate of their crop. In the smaller associations, the manager sometimes secures this information by visiting the orchards in person. This estimate is made early in the fall, or not until damage by worms and other causes is practically over and the crop is secure. With this knowledge in hand, the manager can enter into contracts for delivering certain amounts of various varieties or grades.

The system of selling has been radically changed within the past few years. Formerly practically all of the fruit was consigned to commission men, who, as a class, it may be truthfully said, are inclined to do the best they can by their constituents. But too often the experience has been otherwise. Not infrequently has it happened that shipments consigned to a distant city have been reported as not being up to grade, or not in good condition, so the market price could not be realized. In such cases, though the manager may be certain that his fruit is as he represented, he is often unable

to help himself, so must take what he can get. But of late years, the plan of selling F. O. B. is being practiced more and more, and this is largely due to the organized efforts of the associations. Consignments are only made to well known firms, and much of this fruit is sold at auction.

But even with this arrangement difficulties arise, so in order to protect themselves, the larger associations have an agent at the more important distributing points. It is the duty of the agent, or broker, to inspect all cars which come into his territory, as near the destination as possible, and thus protect the association from dishonest buyers. He also is on hand to adjust the differences which arise when the fruit actually reaches the buyer in poor condition.

Express shipments are only made to comparatively near-by points, and with such shipments, the growers receive exactly what the fruit brings less the expressage and the association's commission. It is usually the early fruits that are expressed, but prohibitive rates prevent any very large amount of business being done in this way.

An association, well managed, is always a benefit to the entire community, in that it builds up a reputation for the fruit, and holds up prices, inasmuch as there is not that tendency, even among non-members, to bid one against another in marketing. This is well illustrated in the case of a prominent fruit grower who is a member of one of our successful associations. Because of superior ability as an orchardist and having a large orchard of choice varieties, he could easily get a price somewhat in excess of that which he receives through the association. But he realizes that it is the association which has built up and sustains the reputation of the locality, and should it fail, the chances are that local competition would again lower prices.

In addition to this, it may be said that the managers are constantly insisting on the necessity of growing better fruit, and so have been instrumental in introducing new and improved methods of culture and, in many instances, have been advance agents for the Experiment Station, and in this capacity have made our work pleasant, as well as acceptable, to the fruit growers.

The Northern District—By the Northern District is understood the territory which is adjacent to Denver and the country north along the foothills to Fort Collins. Associations are operating in most of these towns, but as small fruits are the principal crops handled, express shipments are the rule. The managers find that, usually, it does not pay to make F. O. B. sales of small fruits to the retail dealers, for the reason that such stores change hands frequently, consequently many bad debts result. This is the prin-

cipal difference in the management of the associations in the different sections.

The Boulder County Fruit Growers' Association at Boulder, has been the most successful. Its success is undoubtedly due to an efficient manager and a board of directors who have been content to let the manager handle the business.

With a much smaller volume of business and a much more perishable product, association management is more difficult than in many other localities. Yet the Boulder Association has not failed to make a good dividend on the stock every year since its organization. This is also one of the few which have branched out into other lines and have thus been enabled to do business throughout the year.

The examples cited are of successful institutions which have been in operation a sufficient length of time to thoroughly demonstrate the practibility of the system.

It must not be inferred, however, that other sections of the State have neglected to take advantage of the opportunities which combination in marketing affords.

Several associations in the Arkansas Valley have become prominent, but their management does not differ from that which has already been described.

The following list of fruit and produce and cantaloupe associations, which are now doing business in the State, will show what an important factor this method of selling horticultural produce has become:

LIST OF FRUIT AND PRODUCE AND CANTALOUPE ASSOCIATIONS NOW DOING BUSINESS IN THE STATE.

Amity Cantaloupe Growers' Association, Amity, Colo.
Bent County Melon Growers' Association, Las Animas, Colo.
Boulder County Fruit Growers' Association, Boulder, Colo.
Capitol Hill Melon Growers' Association, Rocky Ford, Colo.
Delta County Fruit Growers' Association, Delta, Colo.
Denver Fruit and Vegetable Association, Denver, Colo.
Fair Mount Melon Growers' Association, Swink, Colo.
Fremont County Fruit Growers' Association, Canon City, Colo.
Fruita Fruit and Produce Association Fruita, Colo.
Fort Collins Fruit Growers' Association, Fort Collins, Colo.
Fowler Melon Growers' Association, Fowler, Colo.
Granada Melon Growers' Association, Granada, Colo.
Grand Junction Fruit Growers' Association, Grand Junction, Colo.
Branches at Clifton, Palisade and Whitewater.
Grand Valley Fruit & Produce Association, Grand Junction, Colo.
Independent Fruit Growers' Association, Grand Junction, Colo.
Kouns Party Cantaloupe Growers' Association, Rocky Ford, Colo.
Lamar Melon Growers' Association, Lamar, Colo.
La Junta Melon and Produce Co., La Junta, Colo.
Longmont Produce Exchange, Longmont, Colo.
Loveland Fruit Growers' Association, Loveland, Colo.
Manzanola Fruit Association, Manzanola, Colo.

Manzanola Orchard Association, Manzanola, Colo.
Newdale Melon Growers' Association, Swink, Colo.
North Fork Fruit Growers' Association, Paonia, Colo.
Palisade Fruit Growers' Association, Palisade, Colo.
Peach Growers' Association, Palisade, Colo.
Plateau and Debeque Fruit, Honey and Produce Ass'n, Debeque, Colo.
Rifle Fruit and Produce Association, Rifle, Colo.
Roaring Fork Potato Growers' Association, Carbondale, Colo.
Rocky Ford Melon Growers' Association, Rocky Ford, Colo.
San Juan Fruit and Produce Growers' Association, Durango, Colorado, and Farmington, New Mexico.
Surface Creek Fruit Growers' Association, Austin, Colo.
Woods Melon Growers' Association, Las Animas, Colo.

A STATE ORGANIZATION.

Now that local associations have become established institutions, there yet remains to be organized a combination of associations. A state association would perhaps not meet our wants so well as district organizations, since the fruit growing localities are widely separated and their conditions so diverse. It is true that the managers now work together to some extent, particularly on the Western Slope, but they all recognize that a much closer union would be desirable.

Not only would our fruit become better known and better prices result, but economy along many lines would be effected. If one man could have supervision of the sales of all associations, in a given section, the last trace of local competition would be done away with. The railroads, as well as the large dealers, could be dealt with to much better advantage by one man representing a group of associations than by a number of men representing the divided interest of several. Then, in the buying of supplies, one man could not only do the work more economically, but he would be able to get much better rates for the same reasons. The same line of argument would hold good for all phases of association management.

The time is not yet ripe, perhaps, for such an organization, but it is fast approaching. It is safe to say that the complete control of the market situation, to which the fruit growers of Colorado are entitled, will only be realized when such a combination is effected.

THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION.

The following report of the Grand Junction Association will assist in giving an insight into this form of successful co-operation. This Association has been chosen for the purpose of illustration, not because it is the most successful, but for the reason that it is the oldest and is doing the largest business of any in the State. This Association was started in 1891, when a few growers combined and appointed one of their number salesman of their fruit for

the season. This arrangement continued with varying degrees of success up to 1897, when it became apparent that the increased business, if no other cause, would necessitate employing a manager, by the year, who should devote his entire time to the association. Accordingly this was done, and the business has increased year by year, as shown below. That the majority of the stockholders are satisfied with the workings of the Association is proven by their loyalty and by the fact that the capital stock has recently been increased to $100,000, for the purpose of accommodating the increasing number of members.

THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION.

GROWTH OF BUSINESS.

Year.	Paid Growers.	Total Business.	Cars Shipped.
1897	$ 54,085.00	$ 88,937.00	167
1898	21,785.00	43,750.00	89
1899	21,346.00	56,591.00	82
1900	68,323.00	114,590.00	202
1901	98,972.90	153,380.00	256
1902	195,975.15	287,887.15	613
1903	247,188.45	339,305.41	682
1904	437,154.83	557,291.11	1,282
1905	475,763.00	608,403.30	797
1906	555,813.44	814,278.62	1,036

Number of stockholders January, 1907..... 666
Number of shares of stock sold to January, 1907....14,169

STATEMENT FOR SEASON 1906.

Fruit Shipments in Detail.

	Packages.	Amount.	Avg.
Extra Peaches	136,162		
Fancy Peaches	139,917	$207,936.19	.45
Choice Peaches	151,438		
Unwrapped Peaches	33,397		
Carrier Peaches	295	177.04	.60
Total	461,209	$208,113.23	
Fancy Pears	87,157	$100,104.49	1.15
Six Tier and Choice	31,425	20,712.42	.66
Half Boxes Pears	6,007	2,878.73	.48
Total	124,589	$123,695.64	
Fancy Apples	128,369	$129,054.14	1.01
Choice Apples	82,955	46,555.14	.56
Half Boxes	2,725	1,235.02	.45
Total	214,049	$176,844.30	
Crates Plums	16,857	$ 8,765.69	.52
Boxes Plums	8,096	1,896.02	.23
Total	24,953	$ 10,661.71	
Crates Grapes	8,382	$ 7,060.79	.84
Baskets Grapes	2,102	457.91	.22
Total	10,484	$ 7,518.70	
Crates Apricots	8,312	$ 5,263.96	.63
Boxes Tomatoes	3,887	1,395.13	.36
Boxes Crab Apples	322	126.54	.39
Jumbo & Stand Cants	13,087	12,219.21	.93
Pony Crates Cants	2,231	1,083.32	.49
Total	15,318	$ 13,302.53	
Crates Strawberries	1,199	$ 2,794.48	2.33
Crates Cherries	1,276	1,910.17	1.50
Cases Honey	1,652	4,187.05	2.54

Shipments of fruit for the season aggregate 867,250 packages, or 28,805,828 pounds, equal to 1,152 cars of 25,000 pounds each; 1,017 cars by freight, and the balance, equal to 135 cars, by express and local freight.

	Cars
Amount of fruit shipped in car lots	1,01
Potatoes shipped in car lots	1
Total	1,03

Business of 1906.

Merchandise sales	$248,779.2
Fruit sales	565,499.3
Total	$814,278.6
Total amount paid to growers	$555,813.4

Cars Received.

	Cars.
Box shooks	123
Wrapping paper	6
Berry boxes and baskets	3
Spraying outfits	3
Nails	3
Bee supplies	1
Spray materials	22
Salt	7
Oranges and lemons	22
Nuts	2
Paper and paper bags	3
Hay	20
Grain sacks	1
Sweet potatoes	1
Cabbage	3
California potatoes	1
Manitou water	2
Beans	1
Total	224

Cars sent out	1,036
Cars received	224
Total cars in and out	1,260

Where the Fruit Went.

	Cars.
California	33
Colorado	146
Illinois	70
Indiana	1
Indian Territory	18
Iowa	76
Kansas	24
Louisiana	60
Maryland	12
Massachusetts	15
Mexico	3
Minnesota	59
Missouri	31
Nebraska	72
New York	76
North Dakota	1
Ohio	2
Oklahoma	15
Pennsylvania	28
Quebec	2
South Dakota	46
Texas	208
Tennessee	2
Utah	1
Wisconsin	12
Wyoming	4

BY-LAWS OF THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION

I.

The name of the said Association shall be the Grand Junction Fruit Growers' Association.

II.

The objects for which the said Association is created are to buy and sell fruit, vegetables, hogs, meat stock and all the products of Mesa County, both fresh and manufactured; to erect, operate and maintain canning and packing factories and commission houses; to manufacture any and all products of Mesa County; to lease, mortgage and sell said business, and to borrow money for carrying on the same, and to pledge their property and franchise for such purpose. To acquire by purchase, or otherwise, and own real estate, buildings, machinery and all the necessary power and power plants for carrying on said premises, and to lease, mortgage and sell the same.

III.

The term of existence of said Association shall be twenty years.

IV.

The capital stock of the said Association shall be twenty-five thousand dollars, divided into five thousand shares of five dollars each.

V.

The number of Directors of said Association shall be seven, and the names of those who shall manage the affairs of the Association for the first year of its existence are C. W. Steele, A. A. Miller, J. W. Rose, R. W. Shropshire, J. H. Smith, P. A. Rice and A. B. Hoyt.

VI.

The principal office of said Association shall be kept at Grand Junction in the said County, and the principal business of said Association shall be carried on in said County of Mesa.

VII.

The stock of said Association shall be non-assessable.

VIII.

The Directors shall have power to make such prudential By-Laws as they may deem proper for the management of the affairs of the Association not inconsistent with the laws of this State, for the purpose of carrying on all kinds of business within the objects and purposes of the Association.

BY-LAWS.

ARTICLE I.

Section 1. The Board of Directors provided for in the articles of incorporation of this Association, shall be elected annually at the regular annual meeting of the stockholders, as hereinafter provided, and shall hold their office until their successors are elected and qualified.

Section 2. Said Directors shall be stockholders in said Association and shall be fruit growers in Grand Valley and shall be residents of Mesa County Colorado.

Section 3. Any vacancy occurring in the Board of Directors shall be filled by the remaining members of the Board.

ARTICLE II.

Section 1. The Board of Directors shall, as soon as may be, after their election, elect a President and Vice-President from among their number, who shall hold their offices for one year, and at said meeting the said Board shall appoint a Secretary, Treasurer, and Manager, who shall be subject to removal at any time.

Section 2. The Secretary, Treasurer, and Manager, shall each, when required by the Board, give bond in such sum and with such security as the Directors may require, conditioned on the faithful performance of their duties, and to turn over to their successors in office all books, papers, vouchers, money, funds and property of whatsoever kind or nature belonging to the Association, upon the expiration of their respective terms of office, or upon their being removed therefrom, or with such other conditions as may be proper.

Section 3. The President shall preside at all meetings of the Directors or Stockholders. He shall sign as President all certificates of stock, and all other contracts and other instruments in writing, which may have been ordered by the Board of Directors.

Section 4. The Vice-President shall, in the absence of or disability of the President, perform his duties.

Section 5. The Manager shall have full charge of the commercial and shipping department of the Association. He shall receive all money arising from the sale of fruit and other commodities handled by the Association, and pay the same to the parties entitled thereto, and render a true account thereof; and he shall also be the Treasurer of this Association and safely keep all money belonging to the Association, and disburse the same under the direction of the Board of Directors, except as herein above set forth.

Section 6. The Secretary shall keep a record of the proceedings of the Board of Directors and also of the meetings of the Stockholders. He shall also keep a book of blank certificates of stock, fill up and countersign all certificates issued, and make the corresponding entries upon the marginal stub of each certificate issued. He shall keep a stock ledger in due form, showing the number of shares issued to and transferred by any stockholder and date of issuance and transfer. He shall have charge of the corporate seal and affix the same to all instruments requiring a seal. He shall keep in the manner prescribed by the Board of Directors, all accounts of the Association with its stockholders, in books provided for such purpose. He shall discharge such other duties as pertain to his office, and as may be prescribed by the Board of Directors.

Section 7. These By-Laws may be amended by the Board of Directors at any special meeting thereof called for that purpose, a notice of such proposed amendment being given in the call for such special meeting.

ARTICLE III.

Section 1. The regular meetings of the Board of Directors shall be held at the office of the Company, on the first (1st) day of each month, except when the first day comes on Sunday or legal holiday, then on the following day.

Special meetings of the Board of Directors may be called by the President when he may deem it expedient or necessary, or by the Secretary, upon the request of any three members of said Board.

Section 2. A majority of the Board of Directors shall constitute a quorum for the transaction of business, but a less number may adjourn from day to day upon giving notice to absent members of the said Board, of such adjournment.

Section 3. The Board of directors shall have power:

First—To call special meetings of the stockholders whenever they deem it necessary, by publishing a notice of such meeting once a week for two weeks next preceding such meeting in some newspaper published in Grand Junction, Colorado.

Second—To appoint and remove or remove all employes and agents of the Association, prescribe their duties where the same have not been prescribed by the By-Laws of the Association for their compensation, and require from them or either of them, if deemed necessary for the faithful performance of their respective duties.

Third—To make such rules and regulations not inconsistent with the laws of the State of Colorado and Articles of Incorporation or the By-Laws of the Association for the guidance of the officers and the management of the affairs of the Association.

Fourth—To direct such [illegible] as they may deem necessary for [illegible] and the officers and employes of the Association, and to authorize the President and Secretary to execute any note of the Association with which to raise money to pay such indebtedness.

Section 4. It shall be the duty of the Board of Directors:

First—To cause to be kept a complete record of all their meetings and also to keep the minutes of the stockholders, present full statements at the regular annual meetings of the stockholders showing in detail the assets and liabilities of the Association, and the condition of its affairs in general.

Second—To supervise all acts of the officers and employes, require the Secretary-Treasurer and Manager to keep full and accurate books of account of their respective trusteeships.

ARTICLE IV.

Section 1. At the regular meeting in the month of January of each year the Directors shall declare such dividends upon the capital stock to the stockholders that accumulations of income as may be warranted by the net earnings of the Association for the preceding year.

ARTICLE V.

Section 1. The Board of Directors may whenever they shall deem it advisable, issue as part or parts of the capital stock of the Association as may be necessary to raise funds for the purpose of carrying out the objects and purposes of the organization of the Association, such stock to be sold only upon the following conditions:

First—That not more than three hundred (300) shares thereof be sold to any one person, firm or association of persons.

Second—That such stock be sold only to fruit growers in Grand Valley.

Third—That such stock be sold at not less than par value of Five Dollars ($5) per share.

ARTICLE VI.

Section 1. The annual meeting of the stockholders for the election of Directors shall be held on the second [illegible] Saturday in January of each year, but if for any reason it should not be held on such day, it may thereafter be held at such [illegible] as may be provided.

Section 2. The Board of Directors shall be elected by the stockholders at the regular annual meeting. Public notice of the time and place of holding said annual meeting and election, shall be published for not less than ten days previous thereto, in some newspaper of general circulation published at Grand Junction, and the said election shall be made by ballot of the stockholders in said ground for that purpose either in person or by proxy appointed in writing. [illegible] a majority of the outstanding stock is represented. If a majority of the outstanding stock shall not be represented [illegible] meeting may be adjourned by the stockholders present for a period not exceeding sixty [illegible] days. All elections shall be by ballot, and each stockholder shall be entitled to as many votes as he or she owns shares of stock at said stockholders' meeting, however that no person who is not himself a stockholder shall be allowed to represent by proxy any stock

holder in the said Association.

The persons receiving the greatest number of votes shall be the Directors for the ensuing year, and until their successors are elected and qualified.

ARTICLE VII.

Section 1. Certificates of stock may be transferred at any time by the holders thereof, or by attorney in fact or legal representative. Such transfer shall be made by endorsement on the certificate of stock and surrender of the same; provided, such transfer shall not be valid until the same shall have been noted in the proper form on the books of the Association. The surrendered certificates shall be cancelled before a new certificate in lieu thereof shall be issued, and no transfer of any share of stock shall be valid or allowed upon the books of the Association upon which any deferred payments are due and unpaid, nor which has not been sold and transferred in accordance with the provisions of the By-Laws of the Association.

Section 2. Any stockholder desiring to dispose of his stock in said Association, shall deposit the same with the Secretary of the Association, and the same shall be sold by the said Secretary at not less than par for account of such stockholder, within sixty (60) days from date of such deposit, under the restriction of Section 1, Article 5, of these By-Laws; provided, that if the Secretary shall not have sold such stock at the expiration of sixty days, then such stock may be returned to such stockholder, and be disposed of by him, without restriction or limitation by the Association.

ARTICLE VIII.

Section 1. All members of this Association are required to market all their fruit through the Association and bear their proportionate share of the expenses of handling the same.

Section 2. Any member may have the privilege of selling his own fruit at the orchard, but no sales of fruit shall be made to a dealer in fruit, or to any person who buys to ship outside the county. In case of the sale of the entire crop of any particular fruit or fruits, by reporting the same to the Association, one-half (½) only of the regular commission will be charged.

Section 3. Any member having any grievance or cause of complaint as to treatment of his fruit by the Association, can appeal to the Board of Directors, whose decision shall be final.

Section 4. All members must pack their fruit for shipping in a neat and workman-like manner, and pack the same in standard sized packages, as adopted and in general use by the Association, having placed thereon their name or number.

ARTICLE IX.

Section 1. A purchaser of stock in this, the Grand Junction Fruit Growers' Association, shall hereafter receive of the profits of the Association, in proportion to the money he has invested.

GRADING LIST OF THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION.

Peaches.

Boxes containing 80 peaches or less.....Extra
Boxes containing 81 peaches to 94.....90's
Boxes containing 95 peaches to 108.....108's

All grades must be free from worms and other defects.

Fancy Apples.

Winesap, Grimes Golden, Missouri Pippin, Red Romanite, Gentton, and kindred varieties, must be two and one-fourth (2¼) inches in diameter and up. Jonathan, Arkansas Black, Ben Davis, Gano, Willow Twig, Shackelford, Pearmain, Mammoth Black Twig, Rome Beauty, W. W. Pippin, Mann, Talman Sweet, Dominie, McIntosh, Wealthy, Steele's Red, Lawver, Baldwin, Huntsman, Spy, Minkler, Stark, Smith Cider, Walbridge, Pewaukee, York Imperial, etc., two and one-half (2½) inches in diameter and up, absolutely free from worms and other defects, bright and normal color, and shapely in form.

Choice.

Shall not be less than two and one-fourth (2¼) inches in diameter and reasonably free from worms, in other words, only stock a little below fancy. Throw away your trash, it won't pay freight. We also advise using the diamond pack.

The above rules for sizes do not apply to early summer varieties of apples; we will only ship one grade—Fancy.

Fancy Pears.

Must be free from worms, smooth and of good shape; gross weight, 53 pounds of more. The number of tiers must be stamped on the box.

Choice.

Reasonably free from worms; in other words, only a little below Fancy.

Plums—Prunes.

The large fancy Hungarian, Italian, Botan, Green Gage, Egg, etc., are put up in four basket crates, well filled, net weight 20 pounds, or more. Small varieties, Wild Goose, Mariana, Damson, and the smaller plums of all varieties, in two and one-half (2½) inch boxes, well-filled, net weight 16 pounds, or more.

Grapes.

Concords in 8-lb Climax baskets, and should be well-filled. Muscat, Rose Peru, Tokay, Purple Damascus, Black Hamburg, in four basket crates, same as California, and must weigh 28 pounds or more gross. See rule for packing grapes.

Cantaloupes.

Both standard and pony crates must contain 45 melons and be tight in the crate.

PUT YOUR NUMBER, VARIETY, AND GRADE ON THE UPPER LEFT HAND CORNER OF THE BLANK END OF THE BOX.

Any one who does not know when to pick fruit, or how to pack it, should consult with our Inspector, or their neighbors.

To Dealers.

In ordering peaches by wire or letter, the different grades will be known as Extra, Fancy and Choice. We guarantee our pack to grade as above, and in case they do not, please advise us, giving stencil number.

THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION.

Bulletin 123 January, 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

THE PLAINS

SOME PRESS BULLETINS

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

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*After March 1, 1908.

THE PLAINS

PRESS BULLETINS

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ADVICE TO PLAINS SETTLERS.

BY J. E. PAYNE.*

We recognize it as a fact that many new settlers have taken up residence in the Plains region during the last few months who have merely enough capital to put up houses, break a few acres of sod, and live during the first six months.

The people cannot wait for results promised by the exploiters of "Scientific Soil Culture." They must have results this season. It is to this class of people that we would address the following suggestions:

First. If you have a milch cow give her the best care possible, and get as many more as you can. Sell cream, or make good butter or cheese. Sod cowhouses are within the reach of all who can work.

Second. Keep as many hens as you can take care of. Feed well and protect from coyotes and other beasts of prey. If you can raise turkeys and geese they will pay. Turkeys and geese may be herded by children, and turkeys are the best grasshopper exterminators known.

Third. For field crops on sod, plant early amber cane, yellow Milo maize and corn. The seed used should be grown in the vicinity if possible, if not, choose some early variety. If you are able to do so, prepare a small field for fall wheat.

Fourth. Plant a garden. If you have no well, plant a small plat near the house and water it with the waste water. Bury every drop of waste water beside some vegetable by making a furrow beside the plants and after the water has sunk away fill the furrow with dry dirt. Old tin cans sunk in the ground by the side of hills of cucumbers aid in watering them economically. Punch holes in the bottoms of the cans.

If you have a well, plant a large garden but plant all garden stuff in rows so that it may be cultivated with horse power. Use the water with the same economy that you would if using only waste water. Never flood the ground purposely. If any should be flooded, stir it thoroughly as soon as it is dry enough.

It is a common mistake with beginners in irrigation to try to make water take the place of cultivation. The result is failure. Another

*The writer has fought grasshoppers and drought in Eastern Colorado for many years. Besides early training in Kansas, he was in charge of work on the Plains for the Colorado Experiment Station from 1896 to 1904, as Superintendent of the Sub-station at Cheyenne Wells, and as Field Agent for the Experiment Station. Is now in the employ of the U. S. Department of Agriculture in the Dry Land Division, to be located at Akron, Colo.

common mistake is to plant a larger area than can be watered from the well. Better begin with only a few square rods and extend the area as experience dictates.

In case you cannot irrigate from a well, select a small patch of ground upon which you can turn the flood water from the prairie by means of furrows. If you can make a small reservoir above the patch, do it. The reservoir may hold a few barrels of water until you have time to direct it to the plants which need it. Cultivate thoroughly and keep all weeds down.

Besides the small truck, a good patch should be planted to Mexican beans, early cow peas, watermelons, muskmelons, stock melons, pumpkins, squashes, popcorn, sweetcorn and potatoes. These will sometimes bring good crops without irrigation. Enough should be planted so that a plentiful supply of winter food for the family will be assured. Stock melons are very productive, and if stored in sod buildings, above ground, they will furnish green food for the milch cows during winter. I have grown stock melons at the rate of 20 tons per acre. I have kept ordinary watermelons until the last of November by packing them in hay and storing them in a room where they kept cool but did not freeze. There are varieties of winter watermelons and muskmelons which are good from Christmas until March.

By planting the following seven varieties of sweetcorn on the same day—and often near the last of May—I have had roasting ears from July 26th until September 26th. The varieties were: Cory, Black Mexican, Perry's Hybrid, Stowell's Evergreen, Country Gentleman, Mammoth Evergreen, and Egyptian. The large varieties may be dried for winter use or allowed to ripen to be used parched. Parched sweetcorn is a luxury, but one which is within the reach of the poorest settler. White Pearl and Queen's Golden popcorn have done well for me, and my family have had many meals consisting only of whipped cream and popcorn.

Potatoes, squashes and pumpkins may be grown successfully by keeping up a constantly successful fight against potato beetles and squash bugs. This means to battle almost daily with the pests from the time the potatoes are up until the middle of August, and from the time the squash plants are up until the squashes are ripe. To describe methods of fighting these pests would require volumes, but we advise you to use your ingenuity in killing them. I preferred to kill them with clubs.

Grasshoppers are the worst enemies to field crops, but by keeping plenty of poultry, the grasshoppers will be kept down.

To produce crops of any kind may require an amount of labor which seems enormously out of proportion to the market value of the produce, but we assume that people who have settled here desire to build up homes and they have come here because they failed to get homes elsewhere. It may be a comforting thing to remember that you may not be working any harder here while trying to establish independence than you would be if working by the day for some one for just enough wages to support yourselves.

CROPS FOR UNIRRIGATED LAND.

BY J. E. PAYNE.

After seven years of experience in Eastern Colorado we feel justified in making some recommendations for the use of those who may try crop raising there without irrigation.

Soils. We have never seen any good crops grown without irrigation upon adobe or very heavy clay soils. But upon sandy loam, sandy and medium and light clay soils, we have seen crops raised on a paying basis nearly every year when given especial attention.

Seeding and Culture. The natural vegetation of the country shows that thin seeding is necessary. The buffalo grasses are thin where they do not get the use of the rain which falls, and thick in locations which catch extra water, as in low lands partly surrounded by hills. All crops should be planted thinly, so that they will not need too much water to make the growth high enough to harvest. All crops should be thoroughly cultivated, so as to give them the benefit of the largest per cent of the rainfall. Thorough and clean culture should be pursued until August 1st, whether rain falls or not, as the crop is thus kept in good condition to use rains which fall late in the season; while if the crops are not kept clean, no amount of cultivation after the late rains will take the place of the cultivation which should have been given before. The most important thing next to water—is doing the work at the proper time.

Ground intended for planting in May should be thoroughly disced in March or early in April so as to hold the early moisture.

These remarks refer only to crops which are recommended in this bulletin, and to crops usually planted in rows and cultivated.

Crops to Depend Upon. Eastern Colorado is mainly a stock country, and the needs of the country demand rough forage for wintering stock.

We have found that the sorghums and a few acclimated varieties of corn produce paying crops, taking an average of five year's crops as a basis for estimates. Very few of the sorghums ripen seed in Northeastern Colorado, so if one wishes to produce seed of either *corn* or *sorghum,* he should be careful to plant seed which was grown in the vicinity.

The following table gives the most important facts concerning the varieties best known.

Name.	Sweet or Non-Saccharine.	Produces Seed.	Fodder.	
			Quality.	Quantity.
Early Amber	Sweet	Abundantly	Good	Large
Early Orange	"	Sparingly	"	"
Kansas Orange	"	"	"	"
Colman	"	"	"	Medium
Collier	"	"	"	"
Folger's Early	"	"	"	"
Red Kaffir Corn	Non.-Sac.	"	"	"
White Kaffir Corn	"	"	"	"
Jerusalem	"	Abundantly	Poor	Small
Yellow Milo Maize	"	Sparingly	Good	Medium
White Milo Maize	"	"	"	"
Brown Durra	"	Abundantly	Poor	Small

Broom Corn. Broom corn is usually easily raised. The market price of good brush makes its production profitable or unprofitable and not the amount which can be produced. The fodder and corn always have a ready home market, but broom corn must be sent out of the country.

Mexican Corn. A flint variety grown in Northern Lincoln, Western Kit Carson, and Central Arapahoe counties. Very rich in protein. Some years the ears merely stick out of the ground and the tassels may not be more than two feet high.

There are several other varieties of corn which do well, but they are confined to small neighborhoods and we cannot be sure that much seed could be had.

Planting. Planting should be done with a lister drill. Use from two to five pounds of seed per acre—according to quality of seed.

Cultivation. This should be done as long as possible with the harrow. Then follow with the weeder, and if it seems best, with the cultivator. *Careful* and *thorough* culture must be given. If planted on sod, it may be planted by a special planter drill. If planted on land broken years ago and left unused during recent years, it will not be likely to produce a good crop unless the season is very favorable.

Time of Planting. May 1st to June 10th, according to the conditions. Sorghum does not grow much until warm weather, but it should be planted while the early moisture is in the ground.

With up-to-date tools and plenty of horses one man can plant and cultivate 160 acres in corn or sorghum. He must use gang listers, large harrows and gang weeders in order to do this, but by working in this way the cost of producing feed may be reduced considerably.

The sorghums are as sure to make a paying crop in Eastern Colorado as corn is in Eastern Kansas.

It is the hope of the author that he can help the people to make two steers grow in Eastern Colorado "where one grew before."

DAIRY WORK FOR PLAINS SETTLERS.

H. M. COTTRELL.

Thousands of families are coming to Colorado this spring to locate on farms. Many of them are looking to the dry land sections of the state where no land on which a furrow has never been turned.

The methods of handling the soil, the varieties of seeds used and the handling of the crops after seeding are entirely different from those found profitable in Eastern States. Experienced men who have farmed in two or more states and under widely different conditions do not intend to lose dollars by the time learning the best way while they are putting what methods and practices are most profitable in a new location.

Many of the new settlers have a limited amount of capital, and a failure of even one year would bring suffering to a large number and financial ruin to others.

To these settlers whose means are not sufficient to carry them through a year of crop failure and have sufficient left to grow a crop the second year, it is urged, during the breaking up of a small area only, not over 40 acres or a quarter section, but if money is quite limited, not over 20 acres.

Write to the Experiment Station, Fort Collins, Colorado, for advice as to the best methods of preparing the soil, the best crops to plant together to use and the best method of handling the crops after seeding. This advice will be given gratis and freely.

The new settler should consult with successful farmers who live in his locality, asking from the latter questions that he asks the Experiment Station. Then observing the points that his neighbors and the Station consider best to do, add a part to see if he can get the largest yield from them. The settler must learn something and would often well pay for the privilege of the land he can use crops and is obliged to do the work yourself.

While learning how to raise profitable crops under his new conditions, the farmer will need an income to support his family. One of the best ways to accomplish this is by selling cows and selling the cream or a dairy.

Many cows selected for milking qualities and fed on the native grasses of Colorado alone will produce enough fat to sell from $2 to $3 worth of butter a month. All the requirements are such as these cows usually have, and some of them have them. The farmer, if he cultivates a small farm, will have the help to milk from 10 to 15 cows, and these will give him a daily income of from $20 to $45 a month. Depending on the number and quality of the cows milked.

Selling the cream to the creameries will require much less outlay for building and equipment than will be needed if butter is made on the farm, and will make the work much lighter for the housewife.

whose work is already hard enough when starting in a new home.

The calves should be sold for veal as soon as old enough, and the work saved in not raising them by hand can be put on the crops and in making improveemnts.

The warm separator milk can be fed at a good profit to pigs and poultry, giving another source of cash income to the new settler.

Sorghum should be sown broadcast to be fed in the fall to keep up the flow of milk.

In selecting range cows for dairy work the grade short-horn has been usually found the most satisfactory. The cow should be selected for four dairy points—a good udder, prominent hip bones, a sharp bone at the top of the shoulder and large stomach capacity. The writer selected a carload of range cows along these lines: None of them had been fed grain and several had to be roped before they could be milked. These cows averaged over $40 per head the first year in cream sold to the creamery, and one cow with these points well developed produced $60 worth of cream the first year.

PREPARATION OF SEED BED.

HINTS FOR THE PLAINS.

BY W. H. OLIN.

Crop conditions in Eastern Colorado are so different from crop conditions in the humid region that special attention should be called to them for the benefit of the new settler.

The very best system of tillage may fail to produce a crop some years, but proper soil management and use of acclimated seed adapted to prevailing conditions tend to render crop failures less frequent and harvests therefore more remunerative.

In the farming operations of many parts of Eastern Colorado, where irrigation can not be practiced, the amount of water available to plants is the "limiting condition of success," as Prof. Failyer calls it. Here is found abundance of cheap land, quite fertile, and water is the element that must be most carefully conserved to insure a crop. No rain water must be allowed to run to waste if possible to store it in the soil. Rains on the plains are usually quick dashing rains and the seed should be in such tilth that both upper soil and subsoil will readily absorb the water which falls during the crop season.

The preparation of the seed bed calls for careful plowing, harrowing and sub-surface packing.

Experience demonstrates that the preparation of the soil reservoir (seed bed) of good depth several months before seeding, the thorough culture of the ground before and after seeding, are essentials that very largely determine success in Eastern Colorado. Summer tillage conserves moisture while it renders more plant food available, keeps down weeds, and keeps the soil in good tilth.

Preparing New Ground for Spring Seeding.—It is always a questionable practice to crop newly broken sod in a dry year. The sod usually contains but little moisture and the process of breaking causes one to lose an appreciable portion of it. Suggestive plan: Plow sod land not less than three nor more than five inches deep, turning sod down as flat as possible, and thus prevent its drying out too soon. Follow as closely with disc harrow as practicable, and this with some form of packer, either single or double roll. This will level the sod land above, and firm the soil in the lower portion of the furrow slice, restoring the capillarity where plowing has arrested it. This firmed under-surface soil is thus enabled to draw moisture from below and give good, normal root development. Follow up the packer with either an acme or a good smoothing harrow to produce a good earth mulch to arrest surface capillarity and check evaporation of soil moisture. Follow with the seeder. All small grain should be drilled in with a press wheel drill, followed up with a good spike-toothed or smoothing harrow. It is almost necessary that all tillage operations on sod be with the furrows rather than across them to avoid tearing up the sod and drying out your seed bed. Do not seed broadcast. Make each tillage operation thorough—plowing, disking, firming, harrowing, and seeding.

When the new crop is up, cross harrow to prevent the formation of a crust and giving the young crop a cultivation. Follow up each rain with a good harrowing as long as character of crop will permit.

Early in June prepare seed bed for the fall and following spring's seeding. Try to hereafter seed only on ground which has been given "summer culture" treatment.

Remember that roots of all cultivated crops make their best growth when you provide:

A firm mellow
A warm mellow
A ventilated
A moist
} Soil well supplied with plant food.

Methods of farming which (a) conserve the moisture, (b) prepare a good seed bed, (c) reduce the evaporation to as near the minimum as possible, (d) use good vital acclimated seed, (e) employ a crop rotation which has stock foods prominent, contain at least one money crop, (f) and practice thorough tillage of the ground, often tide the farmer over bad years and insure his success in good years.

SUMMER CULTURE TO CONSERVE MOISTURE.

HINTS FOR PLAINS SETTLERS.

BY W. H. OLIN.

Many hundred farmers, unfamiliar with the soil and climatic conditions of our eastern plains, are this year coming to make homes

on 160-acre farms in Eastern Colorado in regions where crops have not been generally grown. Many of these settlers have but a limited amount of money and can not afford a crop failure. It is feared that this spring crop will be only partially successful, since many of them are farming as they did "back home," and are not using drouth-resistant crops of demonstrated value in their farming operations. This timely suggestion is sent out to prevent crop failure in fall seeding. Preparation of seed bed is the most important thing in farming the non-irrigated lands, and as soon as spring crops are in, the new settler should plow and cultivate his field he expects to seed to fall crops, or the following spring's grain.

Summer culture is an essential of the Eastern Colorado farmer's success. The French found some centuries ago that "manoeuvering" the land—causing the particles of earth to change place by tillage—made it more productive. Experiments now show that summer tillage in our semi-arid lands has an added value—it conserves the moisture, while it renders more plant food available. Good results have been obtained in Eastern Washington, Eastern Oregon, Utah, and many sections of Colorado from summer culture of the land every other season. It has been found that in this way sufficient moisture can be stored from the year's rainfall to mature a crop in many localities.

After the snows of winter have melted in the spring, plow the ground at least seven or eight inches deep. With disc harrow, corrugated roller, imperial pulverizer, or packer, level and firm this ground as soon after plowing as possible, at least not later than each half day, and follow up with smoothing harrow to establish the earth mulch to check evaporation. This mulch must not be too fine, as the winds of the plains will tend to rift the soil or blow the earth mulch entirely away. If possible, stir the surface soil with a good spike-tooth or acme harrow several times through the summer from two to four inches deep. Follow every summer rain with a good harrowing of this "summer cultured" ground, preventing the formation of a crust at the surface. Keep this ground clean—free from weeds.

Ground that has been well cultivated for several years will produce two crops in succession and can be given summer culture the third year. In this way it is possible to grow two crops in three years on well-tilled soil. If a farmer expects to cultivate 80 acres, he should divide it into two crop divisions—cropping 40 acres the first year and giving summer culture to the other 40 acres. This gives him a crop on one half his land each year while he is storing up moisture in the soil reservoir of the other half to make the next year's crop. A farmer on the non-irrigated lands in Weld County last season, after seedng his spring crop, at once prepared his fall wheat seed bed—150 acres. The writer visited his field early in July and found his seed bed in a fine mellow, moist, condition for seeding. Just a few miles from this careful farmer's ranch was a 500-acre field which had been simply plowed and left in that condition to dry out and become hard. Although an inch of rain had fallen the week previous, the writer found the soil in this field in very poor mechanical condition—dry and hard.

This clearly shows how not to do. Farmer No. 1 now has a most promising field of wheat and will undoubtedly be rewarded with a satisfactory harvest.

One of the writer's correspondents, living ten miles south of Akron, Colo., has practiced summer culture for several years. He reports that in the fall, when he seeds his summer cultured land, he often finds from three to five feet of moisture.

The writer knows that this method of summer culture has been practiced in some parts of California for upwards of forty years with satisfactory results.

Use every practical method you can to conserve the moisture. Summer culture keeps the ground in good tilth, keeps down weeds, renders the plant food easily available for the next year's crop, while it stores up the moisture so necessary to the plant in assimilating its food.

ACCLIMATED SEEDS.

HINTS FOR NEW SETTLERS IN EASTERN COLORADO

BY W. H. OLIN.

So many settlers, coming from the humid regions of the central states into Eastern Colorado this spring, are bringing with them the seeds of the crops grown "back home," with which they hope to grow crops in a much drier region, that a word of caution is neccessary.

Difference in altitude, amount of rainfall and general climatic conditions urges the writer to warn the new settler that past experience has shown that it will be hazardous to use any but acclimated seeds of such types of grain, forage and root crops as successful farmers of that locality have demonstrated show fairly good drouth resistant power.

Even with the most vital seed of established worth, in some seasons, lack of timely rains jeopardizes a profitable harvest. Last season one Eastern Colorado farmer seeded a drouth resistant strain of wheat, getting twenty-five bushels of good, sound wheat, and in an adjoining field, with the same seed bed preparation and after treatment, he seeded a wheat from another state of unknown drouth resistant power and got seven bushels per acre of inferior quality.

This is further illustrated in every crop grown on the eastern plains of Colorado. Seed, if you will, your choice imported grain in a seed block of an acre or less, but be sure to secure for the general field, grain that is acclmated to semi-arid conditions. The following crops have proven to be reasonably certain in average years for this region:

GRAIN.

Corn.—(An early maturing corn should always be used)
White Australian Flint.
Swadley Dent, and
"Divide" Dent, or Colorado Yellow Dent.

Wheat.—For Spring—
Kubanka Durum.
For fall seeding—
Turkey Red, or
Kharkov.

Barley.—(A bald barley or beardless type, seeded early.)

Rye.—One of the surest crops for hay or grain.

Oats.—This is not a reliable crop every year, but early types, as the Big Four, Kherson, and Sixty Day, acclimated to that region, have given very good harvest for several seasons.

Flax.—This is a new crop to Colorado, and for two years has done well, but its worth has not yet been fully proven. The writer would urge settlers not to seed this crop extensively until it has been more fully tested. If this seed is used, be sure to treat seed with formalin before seeding. The writer will send directions on request. Get Colorado-grown seed, if possible.

Emmer.—(Commonly called speltz.)—A drouth-resistant feed grain.

FORAGE.

Kaffir Corn, Dwarf Milo Maize,
Early Amber Sorghum, and
Proso, are good forage crops.

ROOTS.

Potatoes, where non-irrigated, or "Divide" seed is used, have proven the best root crop in recent years for the plains region.

Seek to grow that crop which will furnish feed, and plan to make some form of meat production the main product of the farm. Get the seed of a few well-tried crops and plan to seed them early, so the crop may get what early spring rains may chance to fall.

Rate of seeding is very important, since seeding too heavily takes up the limited amount of moisture in the ground, causing the whole crop to "fire-burn." Do not seed as heavy as you did in the central or eastern states. The following table may be suggestive, but rate of seeding will vary with manner of seeding, size of seed and condition of seed bed, so no definite rule can be laid down. Do not seed broadcast, if you can possibly drill in the grain.

Rate of Seeding for Eastern Plains.

	lbs. per acre.
Grain Crops.	
Wheat	30 to 50.
Wheat (Kubanka Durum)	40 to 50.
Barley	35 to 50.
Oats	35 to 50.
Rye	30 to 40.
Emmer or Speltz	35 to 50.
Field Peas	25 to 40.
Proso	6 to 12.
Forage Crops.	
Sorghum (Varies with the method of seeding.)	8 to 20.
Alfalfa	15 to 25.
Meadow Fescue	15 to 25.
Brome Grass	15 to 25.
Vetches	18 to 30.

POTATOES ON THE PLAINS.

BY E. R. BENNETT.

Where potatoes can be grown in this State they have proven one of the most valuable of the farm crops. However, little investigation has so far been made of the methods of culture that are best adapted to the conditions under which potatoes must be grown on the unirrigated lands of Eastern Colorado. Some very good crops of potatoes have been grown in this section in the past year or two, and it is thought possible that considerable acreage may be planted this year.

The methods of growing employed and the best varieties to plant are necessarily different from those used in the irrigated districts, so a word of advice to the new comers may be timely.

While it is advisable for every farmer to plant potatoes enough for the use of the family, we would not advise those inexperienced in the business to plant a large acreage at first. An acre or two, if successful, will more than supply the family needs, and, if unsuccessful, comparatively little will be lost.

Varieties and Seed.—One of the first requisites for success in growing potatoes on the plains is to get seed that is adapted to the conditions. Probably the best is that which has grown under similar conditions for several generations. If that is not to be had, seed from the Arkansas divide (Elizabeth)country, or even from Dakota, Minnesota, or Wisconsin will do. Seed from the irrigated lands should not be used.

Usually the early part of the season suffers less from drought than the latter; therefore, the early maturing varieties are generally better for the purpose than the larger late potatoes. Early Ohio and Rose Seedling have been grown in this State with considerable success in the past and are probably safer to use than some of the common Eastern varieties.

Soils.—Potatoes are grown on nearly all kinds of soils, but the lighter soils that will hold moisture are generally to be preferred. Land that has been cultivated should be selected in preferance to raw land.

Preparation of the Land.—Plow the land to a good depth when in good condition to work as early in the spring as possible. Harrow the land as fast as plowed to form a soil mulch and prevent loss of moisture by evaporation. From the time plowing is done till planting time, the land should be frequently harrowed. If rains come, the land should be harrowed as soon after the rain as the land can be worked without puddling the soil.

Planting.—In most cases the earlier the planting can be done without danger of early frosts hurting the vines, the better. When it is possible to do so, use a machine for planting, for by so doing

the seed is put down into moist soil, while hand work is apt to leave seed covered with loose, dry soil, in which case the seed will be delayed in coming up and a poor stand result. If the seed is planted deep (not less than five or six inches), this trouble will be to a certain extent avoided. If machines for planting are not available, the hand potato planter used in the East will do the work fairly well.

With the limited amount of moisture that is available for the crop, the plants will do better if planted at a greater distance apart than is usually practiced. If the hand planter is to be used, the field can be marked out as for corn and planted in rows both ways. If the machine is used, rows from forty inches to four feet apart with hills twenty inches to two feet apart in the row will probably give the best results.

Cultivation.—After the potatoes are planted, the success or failure of the crop will, to a large extent, depend upon the cultivation given.

The first cultivation should be given soon after the potatoes are planted, before the plants are out of the ground. Set the cultivator to run as deeply as possible to loosen and aerate the soil. The cultivator should be immediately followed by the harrow to smooth the surface and re-establish the soil mulch. After the potatoes are up, frequent shallow cultivation should be given till the vines become too large to work.

WIND-BREAKS AND SHELTER BELTS FOR THE PLAINS

BY B. O. LONGYEAR.

Wind breaks, as the term implies, are plantations of trees or similar plants intended to check the force of the wind. They may be used to lessen the drying effects of hot winds in summer to prevent injury or loss to fruit in autumn, and to shut off the cold winds of winter from yards and buildings. Wind-breaks for the last purpose are usually called shelter belts, and are often made several rods in width.

The location of the wind-break will, of course, depend on the direction of the prevailing winds. For general purposes the north and west sides of the area to be protected are the ones along which the trees are planted in most portions of this state. Shelter belts should be planted far enough from buildings so that drifting snows on the inner side will not be an inconvenience.

The simplest kind of wind-break is one formed by planting some one species of tree in a single row. If a tall-growing tree is used alone in this way there is a tendency for the trees to spindle up and in time the trunks lose their lower branches. Such an arrangement may do very well for a time, or where only partial checking of the wind's force is desired. But where more complete shelter

from winds is desired, it is usually necessary to plant several rows of different species, so arranged that the low, dense-growing kinds will fill in the places between the taller ones.

For the taller-growing tree in this region the common cottonwood may be used, setting them about eight feet apart for the outer or north and west rows. A second row of some denser-growing kind should be planted about eight feet from the first and as close as four feet in the row. For this purpose box elder is a suitable tree, except in dry situations, in which case the green ash is recommended. The trees in the third row may be planted the same as in the second row, using a more compact-growing kind. The Russian golden willow is recommended for this purpose as a rapid grower. The Russian wild olive is a more compact tree of lower growth and is particularly desirable. White or American elm is also a suitable tree for the inner rows in many places, especially where a fair amount of moisture can be depended on.

In cases where the wind is exceptionally strong, it may be found necessary to plant a belt four or five rods wide, in order to secure complete protection. The outer two rows may consist of Russian olive, the third and fourth rows of black locust, the fifth and sixth rows of box elder or ash, the seventh and eighth rows of American elm, and the inner two or three rows of cottonwood or Carolina poplar, the rows being about eight feet apart. The golden Russian willow may be used in place of the elm, and honey locust may take the place of the black locust.

The ground should be prepared as carefully as for a crop of grain or sugar beets. Where the rows are to stand, the soil should be furrowed out each way by making a back furrow between each two rows. When harrowed, the land will slope each way toward the trees thus tending to collect drifting snow where it is most needed.

The same care in planting should be taken that would be given in setting an orchard. Seedling trees, two years old, are better in most cases than large ones, as they will bear transplanting more readily, are easily handled, and the cost is much less than with the larger sizes. Trim off all broken and bruised roots with a sharp knife and cut back the top to correspond. Set the trees an inch or two deeper than in the nursery, and firm the soil about the roots.

As soon as planted, irrigate if water is available. If not, give a shallow cultivation to check surface evaporation from the soil.

Cultivation should be continued during the growing season, especially after each rainfall. This is particularly necessary on the plains or where water for irrigation can not be supplied. Such cultivation is calculated to keep a thin layer of fine, dry soil on the surface, which acts as a mulch to conserve moisture. Such care should be continued during the first three to five years, or until the trees shade the ground between the rows. A mulch of old straw at this time may be placed between the rows, and will assist the trees in keeping down the grass and weeds.

Pruning is not desirable, unless it be so done as to cause a thicker growth. Thus in the case of the willow, many smaller stems may be secured by cutting out the main trunk a foot or so above the ground when four or five years old. In this way a single, or, better still, a double row of willows, closely planted, may be used as a hedge, which will also serve as an effective wind-break.

GRASSHOPPERS UPON THE PLAINS.

BY C. P. GILLETTE

The western plains have long been noted for their hordes of grasshoppers. The reputation is chiefly due to the great swarms of the "Destructive" or "Rocky Mountain Locust" that used to fly out from the mountains in numbers sufficient to destroy all crops in a few hours, wherever they stopped. This pest is no longer to be feared in Colorado, but there are several species of locusts (grasshoppers) that are present every year and often in destructive numbers. The habits and remedies for the most of these may be given in a general way as follows:

Life History.—During the fall months the female locusts deposit their eggs in little pockets, an inch to an inch and a half deep, in the ground. The eggs are found in largest numbers along road sides, ditch banks and the borders of fields. They hatch about as soon as green vegetation starts enough to give the little hoppers plenty of tender, nutritious food.

If plenty of food is at hand, the little grasshoppers do not wander far from the place of hatching for a few days, and their presence may be noticed by the perforated and ragged leaves of weeds as well as cultivated plants where they are feeding.

By the middle of July, a few of these locusts will have wings, which means they are fully grown, but few, if any, eggs will be deposited before the middle or latter part of August. Very soon after a female has laid her eggs she dies, and there are some of the later individuals that do not finish egg-laying until they are killed by the cold, freezing nights late in November. There is but one generation or round of development of the locust in a year.

Destruction of Eggs.—The eggs of locusts are very soon killed by being exposed to the dry air and sunshine of Colorado, so if it is known that there are many of the eggs in meadows, alfalfa fields, along road sides or ditch banks, it is an excellent plan to plow or thoroughly harrow the infested ground during the late fall, winter, or early spring. It will pay well to harrow the alfalfa just because of the increased crop of hay that will result, even if there are no locust eggs.

Destroying the Locusts.—The little hoppers, when very abundant about the border of the fields or along ditch banks ,can be largely killed by a thorough spraying with arsenate of lead, 3 pounds to 50 gallons of water, or Paris green, ½ pound to 50 gallons, as for other insects. A narrow strip, not to exceed a rod in width, sprayed early in spring, will not endanger stock eating the hay later on, but care should be used not to put stock upon sprayed areas too soon.

Where straw is available, it may be spread lightly over ditch banks and other places where the hoppers are abundant and be burned In gardens and among potatoes and other vegetables poisoned bran can often be used with success. Mix 1 pound of Paris green with about 40 pounds of bran, add just water enough to moisten the whole, and then sow it broadsast where the hoppers are most numerous. If this poison is used, care must be taken to keep chickens and other domestic animals from the poison for some time.

One of the simplest and often a very effectual remedy is to grow plenty of chickens and turkeys to range over the infested grounds. Wherever coyotes abound, however, precautions must be taken to protect turkeys and chickens at night. Turkeys are very profitable, if raised with proper care, as they protect crops from destruction, forage nearly their whole living, and sell at a high price in the fall or winter.

Hopper "dozers" or pans are also very successful where they can be used. Anyone wishing directions for making a good hopper pan should write the experiment station for a copy of Bulletin No. 112.

I shall always be glad to receive inquiries concerning insects that are doing damage in any part of the State. Send specimens of the insects when possible, with samples of their injuries.

RAISING HOGS ON THE PLAINS.

BY H. M COTTRELL.

Farmers living in the Plains regions of Colorado will find it advantageous to give special attention to the raising and fattening of hogs.

The surest grain crops under the dry land farming are barley, wheat, milo maize and Kaffir corn, all four are good feeds for the production of pork.

Barley is the best of all grains for the production of pork of fine quality and flavor. It requires less water to mature a crop than any of our other common grains, and when seeded early is the surest grain crop on the Plains. Many growers on the Plains report an average yield of 2,000 pounds of barley an acre, and this is sufficient to produce over 400 pounds of gain when fed to hogs.

Wheat will produce as much pork as the same weight of corn, and many farmers have found it profitable where rainfall is limited

to raise Durum wheat and fatten hogs with it. Wheat does not produce pork of the first quality and it is best to feed barley the last 30 days of fattening, as it makes the pork finer, the fat whiter, and greatly improves the flavor.

Rye is profitably fed in some sections. It will make good gains, but the hogs should be finished on barley.

Milo maize and Kaffir corn will produce about 90 per cent. of as much gain on hogs as will an equal weight of corn, and are very profitable grains to raise for feeding hogs. Both of these grains are constipating and need some laxative feed to be given with them. Alfalfa hay is one of the best feeds for this purpose, sorghum hay is good, as are also any kind of roots.

Hubbard squash is an excellent feed for fattening hogs and some Colorado farmers use it as an exclusive feed for this purpose, but better gains and finer quality of pork will be secured when some grain is given with it.

A mixture of two grains will give larger gains than the same weight of one grain fed alone.

Dairying is one of the surest and most profitable lines of farming on the Plains, and skim milk fed with grain to pigs and hogs is one of the best of feeds. Hog raising increases the profitableness of dairying.

Grain is high-priced in most sections of Colorado, and while a hog should have some grain every day of his life, at least half the weight of a 200-pound hog should be made from roughage—pasture or fodder. The best pasture is alfalfa, and there are few farms on the Plains but what have some spot where alfalfa will thrive if proper methods are followed, and seed from non-irrigated land is used.

Dwarf Essex rape stands drought fairly well if seeded as soon as the frost is out of the ground. Winter wheat and rye make good early pasture, and sorghum may be seeded in the spring in fields of rye or wheat and will furnish pasture after the grain has dried up.

Good alfalfa hay is the best winter roughage to feed hogs. It can be fed in a rack and will increase the gains and improve the flavor of the pork. In a test made by the writer, hogs fed all the grain they would eat gained 400 pounds, while those fed alfalfa hay and grain gained 600 pounds.

Where alfalfa hay is not available good, juicy, sorghum fodder improves the thriftiness of hogs and increases the gains.

Hogs should have access to salt and charcoal or coal at all times, and wood ashes are beneficial. Good water plentifully supplied is as essential in making gains as is grain.

The Plains section of Colorado has great advantages for raising hogs. The grains most profitable to grow there produce finer flavored pork than corn, and usually the grain can be marketed at a higher price when fed to hogs than when sold on the market. This is especially true where the quality of the grain is inferior.

Denmark sells eighteen million dollars worth of bacon a year to England alone. The Danish bacon sells for a considerably higher

price than the best quality of corn fed bacon. The Danish bacon is made from barley-fed hogs.

TYPES OF MILLING WHEAT FOR THE PLAINS.

BY W. H. OLIN.

Winter Wheat.—The Plains farmer has found in the past that wheat is to him a desirable cash crop and when acclimated seed of wheat types having known drouth resistant power, is used, the probabilities for harvest are increased.

The type of winter wheat which for the past five years has been giving best results is Turkey Red. It has a medium straw, a medium to short spike, a small kernel, but is recognized as one of the best of milling wheats. Nearly every mill in the state is ready to pay from 5 cents to 10 cents premium for this wheat, so it has a strong local trade, insuring farmers a good market for the threshed grain. This grain should be seeded on good summer cultured ground at such a time after the middle of September and before the middle of October, as local conditions render advisable. When moisture conditions are such that his wheat gets a good start before it goes into the winter, it has a stem and root growth which enables it to more readily withstand winter conditions and the desirable strength in the spring for sturdy growth. An appreciable amount of winter moisture is very desirable for this crop.

Early fall and late spring rains are essential for a fully developed crop and a satisfactory harvest. Use acclimated seed if possible. Some careful farmers in the vicinity of Holyoke, Vernon, Bennett, Byers and other localities of the Plains, have raised creditable winter wheat this past season, and the writer will be glad to assist, as far as possible, the new settler to get good quality acclimated seed grown under his local conditions.

When the seed bed is well prepared under summer culture conditions, good vital, acclimated seed is properly drilled in the seed bed, (do not broadcast) at least three weeks before the close of the growing season, the farmer has done his part well. This should be followed by cross-harrowing in the spring. This gives cultivation to the growing wheat and thereby invigorates it.

Get and keep pure quality seed.

Spring Wheat.—Kubanka Durum for the past four years has shown itself to be our most drouth-resistant spring wheat for the Plains. While Colorado millers have not used it very extensively for milling, several export dealers are lending encouragment to the growing of this grain, and an increasing export trade east and south seems assured. Besides, this grain is being utilized by many farmers, mixing it with other grains for feeding purposes.

It is our very best poultry food, and crushed and soaked with barley or rye, makes a very good hog food.

This wheat, when made into flour, furnishes a rich, nutritious flour, bread made from which has a rich, creamy color, a nutty flavor, holds moisture longer than bread from the common spring wheat flour, and tests made by the writer show that very satisfactory bread, biscuits and pastry can be made from straight Durum flour.

A few Kansas and Colorado millers are successfully milling this wheat, and should Plains settlers call for and use this flour, the growing and milling of Durum wheat on the Plains will be greatly encouraged.

There are fifteen types of Durum wheat grown in this country. Some types have little or no milling value. White Kubanka Durum (the type recommended for the plains) *will make good quality flour,* and also superior macaroni. This wheat should not be grown under irrigation where a hardy winter wheat has proven itself a well-acclimated grain. It is recommended for those regions of the Plains of Colorado where other wheats are not successfully grown. It is one of our most drouth-resistant spring grains, but is heavily bearded. Colorado No. 50 wheat and White Sonora are showing fairly good drouth-resisting power, but not equal to Kubanka Durum. Both of these are beardless types of spring wheat.

Seed your spring wheat on a well prepared seed bed as early as weather conditions will permit. The earlier seeded, usually the better the grain starts, and it is more likely to blossom and fill before the drying winds come to check development.

Plains farmers are urged to grow their own *bread,* as well as *meat,* and thus "Keep the wolf from the door."

RAINFALL ON THE PLAINS.

BY L. G. CARPENTER.

In some current discussion it seems to be forgotten that all moisture must come ultimately from the rainfall, and, therefore, unless increased by drainage or other source, the amount available for crops must be limited to the amount of rainfall or by the amount absorbed which is considerably less. While land favorably situated may have an advantage from its location, and derive water from neighboring land, there is no method of cultivation which will manufacture moisture. The most to be expected is to lessen the losses, by evaporation and otherwise, which normally take place, and possibly to take advantage of favorable location. In depressions or valleys, some water may be received, none the less important because invisible and underground, usually the drainage from higher land. In such locations, the crop may use much more than the local rainfall, hence where crops are

grown but a little they must receive additional waters no less effectually than by surface irrigation. To say they are raised by the natural rainfall is misleading, to say the least.

Many inquiries are asked concerning the amount of rainfall on the plains and some misunderstandings are prevalent. These may best be answered by giving the records of a number of places where the rainfall has been measured for a series of years. These which have the longest record are chosen.

To accompany the rainfall records the distribution and character of the rainfall must be taken into account as well as the amount. It scarcely needs to be said that a moderate rainfall which falls mostly in the growing season, without long intervals between rain, moderate showers is far more effective that a large rainfall coming principally in the cold season, or which comes in heavy showers at irregular and infrequent intervals. Sudden and heavy downpours are of little agricultural value for the effectiveness of a rain is largely measured by the amount which the soil absorbs and this absorption takes place at a slow rate, varying with the soil, but, say, one inch per hour. Showers of a few hundredths of an inch are of little value, for they penetrate only the surface of the soil, evaporate almost immediately, and thus are of practically no benefit. Hence moderate rainfalls, well distributed during the growing months are of the greatest value. A favorable feature of the distribution of the rainfall in Colorado, is that nearly 50 per cent comes in these growing months. On the divide between the Arkansas and the Platte rivers, more falls in the summer months of June and August. Speaking generally in respect to the plains, the storms of long continuance are mostly in the months of April and May (or perhaps the latter part of June and October, while the thunderstorms of the summer have their precipitation principally in the form of thunder showers.

Even the average rainfall for any given month may be misleading, and especially where the rainfall is moderate or small, and subject to occasional violent storms. The average may be far from indicating the probable quantity to be expected. More than half of the years will be below the average. A better index to the agricultural value of the rainfall is to know the certain variety of a given rainfall which can be depended on. We may take the record of April at Fort Collins to illustrate the difference. While the average for 25 years is 2.31 inches, the record shows that practically three out of four years (18 out of 24) have been below the average. Hence so far as this is a guide for the future, the probability is about three to one that in any given April, the rainfall will be below the average.

If, however, we count the Aprils with reference to the amount, we find that, for a quantity of about 1.22 inches, half of the Aprils have been above and half below. This amount is the safer guide of what to expect. For lack of a better term, I have called this the agricultural mean as distinct from the ordinary average, and it is indicated at the foot of the table. Where there is little difference

between the average and the agricultural mean, it indicates that the rainfall in the month is quite certain.

The records which are given in connection with this bulletin are the records of the stations which have maintained the records for the longest period of time. These include Fort Collins and Denver, on the plains within a few miles of the foothills, and both at an elevation of practically 5,000 feet. Rocky Ford is in the Arkansas Valley about sixty miles east of Pueblo, at an elevation of 4,176 feet. Leroy, (elevation 4,380 feet), Wray, (elevation 3,531 feet) and Yuma, (elevation 4,147 feet), are in Northeastern Colorado; Cheyenne Wells in the Eastern Central (elevation 4,279 feet), and Hamps on the divide between the Arkansas and Platte rivers. The length of record of these stations ranges from 11 to 37 years.

A critical examination indiactes that when changes occur at one station they generally indicate a corresponding change at other stations, but that the increase or decrease is not the same. This is due to the fact that while there are many storms which are general in character, there are also local storms which affect a lesser area. Generally speaking, the rainfall decreases for some distance from the mountains on the plains, and then increases toward the eastern border of the state. It increases with elevation, and prominent ridges, like the divide between the Arkansas and Platte rivers, show an increase or change in the character of the distribution, which materially helps the availability of the supply.

While it is not safe to conclude that the rainfall of the whole eastern part of the state has increased becase the percipitation at one station has increased, yet generally, there is some parallelism.

An examination of the table indicates a marked increase in all the stations for 1905 and 1906 over the average for a period of years. This is shown by the following summary:

Place.	No. Years on Record.	Average.	1905.	1906.	1907.
Denver	37	13.37	17.68	16.84	11.83
Fort Collins	27	14.92	19.86	19.88	11.64
Wray	11	19.25	22.43	23.09	14.23
Hamps	14	14.56	23.60	19.07	10.56
Yuma	16	17.77	23.76	20.76	13.53
Leroy	17	16.06	22.18	21.80	16.57
Cheyenne Wells	16	16.58	18.31	19.46	9.72
Rocky Ford	18	13.15	14.39	14.66	13.59
		125.66	162.21	155.56	101.67

The tables give the monthly rainfall. At the bottom is given the average for the whole period of the record. Manifestly in comparing the percipitation in two different stations, it is important that the same years be considered at both places, or the same months. These tables were made up in the summer of 1907 and thus 1907 was omitted. For convenience, it is given in a separate table by months, but not used in determining the averages or agricultural mean.

PRECIPITATION AT DENVER, COLORADO. *U. S. Weather Bureau*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1870	1.80	1.70	0.70	2.80	0.34	0.52	0.51	0.12	2.85	0.68	0.54	0.73	13.29
1871	0.46	0.23	1.81	1.01	2.56	0.05	0.51	0.27	1.18	0.40	3.10	0.77	12.35
1872	0.55	0.22	1.71	2.09	3.74	2.07	2.69	1.75	1.57	0.68	0.69	0.29	18.05
1873	0.13	0.34	0.22	2.43	0.75	2.24	2.00	1.41	0.89	0.73	0.16	0.61	11.81
1874	0.84	0.53	0.49	1.70	2.43	1.21	3.35	0.68	1.34	0.64	0.08	0.17	13.46
1875	0.38	0.60	0.39	2.24	1.94	0.43	4.32	1.97	2.89	0.22	1.28	0.59	17.25
1876	0.21	0.11	1.80	1.22	8.57	1.10	1.16	2.03	0.60	0.12	1.50	1.70	20.12
1877	1.90	0.40	1.40	2.77	2.30	1.93	0.23	1.30	0.38	2.15	0.73	0.79	16.28
1878	0.10	0.48	1.82	0.05	2.90	2.78	1.38	2.25	1.23	0.80	0.67	1.05	15.51
1879	0.40	0.39	1.00	2.62	3.36	0.32	0.64	1.38	0.02	0.19	0.21	0.33	10.86
1880	0.38	0.32	0.21	0.31	1.11	1.22	1.38	1.46	0.89	1.37	0.83	0.10	9.58
1881	0.49	1.22	0.87	0.50	2.21	0.09	2.50	2.33	0.57	0.32	1.68	0.00	12.78
1882	0.57	0.20	0.20	1.47	2.98	4.96	0.66	1.20	0.06	0.75	0.71	0.73	14.49
1883	2.35	0.45	0.21	3.10	4.30	0.85	2.27	0.75	1.08	1.49	0.32	2.32	19.49
1884	0.22	0.86	0.93	3.33	4.61	1.47	0.65	1.71	0.13	0.21	0.19	0.76	15.07
1885	0.41	0.25	0.97	4.94	2.13	0.66	1.33	1.18	1.22	0.73	0.55	1.08	15.95
1886	0.62	0.72	2.36	2.79	0.09	2.26	0.50	1.62	0.98	0.33	1.93	0.87	15.07
1887	0.67	0.30	0.23	2.16	1.13	0.53	2.49	2.68	0.97	0.97	0.22	0.14	12.49
1888	0.11	0.37	1.15	1.71	2.66	0.29	0.41	1.51	0.11	0.77	0.33	0.09	9.51
1889	0.50	0.70	0.40	1.34	3.44	1.88	2.94	0.33	0.28	2.11	0.53	0.30	14.75
1890	0.18	0.46	0.35	2.50	2.01	T	0.79	1.89	0.17	0.64	0.30	0.04	9.33
1891	1.60	0.27	3.10	2.49	4.15	2.93	0.59	2.84	0.73	0.48	0.69	1.56	21.43
1892	0.40	0.75	1.20	1.75	2.14	1.33	1.19	0.58	T	3.92	0.44	1.32	15.02
1893	0.05	0.83	0.23	0.87	3.09	0.13	1.14	0.35	0.05	0.84	0.55	0.35	8.48
1894	0.18	0.90	0.70	3.30	3.00	0.39	2.11	1.86	1.55	0.19	0.22	0.69	15.09
1895	0.32	0.48	1.19	1.19	2.86	2.65	4.28	0.76	0.98	1.13	0.27	0.01	16.12
1896	0.25	0.24	1.43	0.93	1.27	0.89	2.80	0.97	1.81	0.84	0.10	0.31	11.84
1897	0.58	0.82	0.90	1.31	3.15	2.16	2.06	1.44	0.44	1.64	0.24	0.63	15.37
1898	0.20	0.68	0.28	1.20	4.88	0.94	0.67	0.96	0.28	1.05	0.85	0.99	12.98
1899	0.65	0.58	1.10	0.75	0.15	0.47	1.92	1.78	0.20	1.01	T	0.72	9.33
1900	0.13	0.55	0.63	8.24	0.53	1.87	1.30	0.05	0.87	0.33	0.37	0.42	15.29
1901	0.05	0.06	0.88	1.96	1.18	2.09	0.01	1.30	0.22	0.46	T	0.89	9.10
1902	0.17	0.38	0.63	0.60	1.98	1.89	1.24	0.76	3.70	0.80	0.61	0.59	13.35
1903	0.12	0.42	0.87	0.81	0.75	1.62	1.36	1.35	0.56	1.34	0.07	0.23	9.50
1904	0.04	0.17	0.94	0.74	3.27	3.54	2.13	0.60	1.77	0.40	0.04	0.41	14.05
1905	0.99	0.35	3.07	4.95	2.65	0.61	1.55	0.67	0.49	2.31	0.04	T	17.68
1906	0.17	0.06	1.88	3.67	1.45	1.51	1.21	0.88	2.72	1.98	1.30	0.01	16.84
Average 37 years	0.52	0.51	0.97	2.10	2.49	1.40	1.57	1.27	0.97	0.95	0.60	0.61	13.96
Average 20 years	0.37	0.47	1.06	2.12	2.28	1.38	1.61	1.18	0.89	1.16	0.36	0.49	13.37
Max.	2.35	1.70	3.10	8.24	8.57	4.96	4.28	2.68	3.70	3.92	3.10	2.32	....
Min.	0.04	0.06	0.21	0.05	0.09	T	0.01	0.05	T	0.19	T	0.00	.....
Agr. Mean	0.38	0.45	0.90	1.75	2.43	1.22	1.33	1.30	0.87	0.75	0.44	0.59	12.41

PRECIPITATION AT AGRICULTURAL COLLEGE, FORT COLLINS, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1872	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1873	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.02	0.20	.....
1874	0.25	0.16	0.00	1.20	2.30	1.50	1.30	0.85	0.75	0.42	0.20	0.17	9.10
1879	0.06	0.43	1.29	0.77	2.95	0.65	3.15	0.25	0.00	1.00	0.02	0.00	10.57
1880	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.75	0.15	0.60	.....
1881	0.72	1.09	0.38	0.94	0.60	0.86	1.80	0.37	1.47	2.07	1.10	0.10	11.50
1882	1.10	0.55	1.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1883	.....	.....	0.17	.....	4.67	3.07	1.76	0.89	2.51	0.82	0.29	.....	.....
1884	1.00	1.50	0.68	.....	2.51	3.18	.....	1.78	1.00	1.29	T	1.33	.....
1885	1.10	0.70	1.15	3.94	4.84	.....	.....	.....	.....	0.10	1.80	0.35	.....
1886	1.77	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1887	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.69	1.18	0.33	.....
1888	0.86	0.23	0.25	1.10	1.23	1.96	3.05	2.12	0.54	0.43	0.15	0.00	11.92
1889	0.29	0.36	0.73	1.23	3.39	0.47	0.60	1.01	0.29	0.88	0.38	0.16	9.79
1890	0.21	0.34	0.65	2.07	3.39	2.06	0.79	0.95	0.42	3.16	0.43	0.01	14.48
1891	0.13	0.21	0.22	3.92	1.19	0.12	1.27	3.14	0.07	0.70	0.32	0.12	11.41
1892	2.32	0.16	1.20	2.14	4.07	1.30	0.17	2.05	1.02	0.20	0.60	0.46	15.70
1893	0.60	1.29	1.52	1.60	4.83	2.42	1.32	0.22	0.14	0.93	0.23	0.35	15.45
1894	0.02	0.54	0.14	1.66	1.92	0.26	0.64	0.92	0.18	0.16	0.55	0.12	7.11
1895	0.25	0.60	0.67	0.89	3.09	0.42	1.72	1.53	2.29	T	0.14	0.76	12.36
1896	0.24	1.52	0.54	1.36	3.62	3.65	3.75	1.45	0.47	1.06	0.40	0.01	18.07
1897	0.43	0.03	1.73	1.26	1.68	3.05	3.05	2.20	1.55	0.49	0.05	0.24	15.76
1898	0.18	0.54	2.15	1.39	2.06	1.69	2.65	1.74	0.75	0.75	0.67	0.67	15.24
1899	0.14	0.08	0.50	1.08	3.65	1.37	0.50	0.98	0.50	0.82	1.24	0.17	11.03
1900	0.66	1.04	1.50	1.10	1.01	1.03	4.95	0.99	0.21	3.23	T	0.47	16.19
1901	0.25	1.12	1.07	10.56	1.75	0.82	1.14	0.16	1.92	0.24	0.07	0.11	19.21
1902	0.19	0.38	1.88	3.62	7.47	2.35	0.71	0.72	2.10	0.36	0.02	1.37	21.17
1903	0.32	0.15	1.50	0.61	2.13	2.43	1.31	0.67	7.12	1.15	0.27	0.77	18.43
1904	0.16	1.60	1.03	1.50	0.63	2.23	1.06	0.86	0.87	1.70	0.18	0.07	11.89
1905	0.04	0.34	0.51	0.89	5.37	1.68	1.99	0.71	1.09	0.39	0.00	0.12	13.13
1906	0.29	0.35	1.75	6.32	4.13	0.64	2.18	1.25	0.28	2.60	0.07	T	19.86
	0.01	0.03	2.44	4.30	2.40	1.80	1.96	0.80	3.08	1.59	1.35	0.12	19.88
Average	0.50	0.59	1.00	2.31	2.96	1.64	1.78	1.14	1.22	1.04	0.41	0.33	14.92
Average 20 Years	0.38	0.55	1.10	2.43	2.95	1.58	1.74	1.22	1.24	1.04	0.36	0.34	14.93
Max.	2.32	1.60	2.44	10.56	7.47	3.65	4.95	3.14	7.12	3.23	1.35	1.37	.....
Min.	0.01	0.03	0.14	0.61	0.63	0.12	0.50	0.16	0.07	T	O	0.00	.....
Agrl. Mean, 20 Years	0.24½	0.34½	1.05	1.44½	2.74½	1.68½	1.31½	0.98½	0.64½	0.78½	0.25	0.14	11.63

Observers—1880, F. J. Annis; 1881, A. E. Blount; 1882-5, C. F. Davis; 1886-7, E. Mead; 1888-1906, L. C. Carpenter, R. E. Trimble, Assistant.

PRECIPITATION AT WRAY, YUMA COUNTY

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	'Nov.	Dec.	Year.
1890	.....	.....	T	T	4.44	1.42	0.62	0.25	1.09	0.45	0.25	T	.....
1891	1.80	0.50	1.90	4.68	2.02	4.55	2.52	0.45	1.24	O	0.20	0.83	20.69
1893	.....	.....	.....	0.03	2.12	1.00	.....	.....	.....	.....	.....	.....	.....
1895	.....	.....	.....	.....	.....	.....	.....	.....	.....	T	0.12	0.32	.....
1896	0.47	0.02	0.66	4.83	1.64	3.77	1.13	1.47	1.01	1.37	0.06	0.20	16.63
1897	0.28	0.26	1.79	1.64	3.34	4.79	1.79	2.27	0.73	2.92	0.07	0.31	20.19
1898	0.06	0.07	0.83	1.73	5.47	2.98	1.88	2.56	2.33	0.25	0.26	0.29	18.71
1899	0.63	0.07	0.50	0.62	1.96	1.83	2.18	1.38	0.08	T	1.16	0.33	10.74
1900	0.16	0.90	0.33	6.00	0.61	2.35	4.57	2.60	0.15	0.03	0.20	0.34	18.24
1901	T	1.37	2.51	4.02	0.28	3.40	2.05	5.36	2.11	0.43	T	0.91	22.44
1902	0.20	0.74	1.05	0.74	7.00	5.69	3.33	2.71	3.73	1.05	0.16	0.59	26.99
1903	0.25	1.98	0.16	0.54	1.95	1.55	5.16	1.48	0.69	0.34	0.25	T	14.35
1904	T	0.58	0.04	2.46	2.02	6.25	2.00	1.26	1.74	1.19	0.05	0.20	17.79
1905	0.04	0.05	3.10	5.12	2.59	3.19	2.98	0.93	2.19	1.64	0.60	T	22.43
1906	0.55	0.62	1.88	4.82	3.20	2.57	1.62	3.57	1.71	1.43	0.83	0.29	23.09
Means	0.24	0.61	1.17	2.96	2.73	3.49	2.61	2.33	1.50	0.97	0.33	0.31	19.25
Agrl. Mean	0.20	.58	.83	2.46	2.02	3.19	2.05	2.27	1.71	1.05	0.20	0.26	16.82
Max. for Month	0.63	1.98	3.10	6.00	7.00	6.25	5.16	5.36	3.73	2.92	1.16	0.91	.....
Min. for Month	T	0.02	0.04	0.54	0.28	1.55	1.13	0.93	0.15	T	T	T	.....

Established by the Colorado State Weather Bureau. Observer—J. C. Tuomey.

PRECIPITATION AT HEMPS, ELBERT COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1893	0.02	0.08	0.02	0.24	1.60	0.70	3.07	1.23	0.27	0.16	0.04	0.19	7.62
1894	0.07	0.29	0.54	1.11	4.10	0.51	1.65	1.23	1.19	0.05	0.02	0.17	10.93
1895	0.15	0.42	0.28	0.85	2.05	3.79	4.07	2.08	0.12	0.15	0.10	0.11	14.70
1896	0.52	0.30	1.25	1.22	1.05	0.70	3.42	2.80	0.65	0.57	0.02	0.28	12.78
1897	0.14	.....	.....	0.49	0.70	1.68	1.35	6.21	0.42	0.96	T	0.22	.....
1898	0.04	0.02	0.20	0.96	3.80	1.03	1.84	1.61	1.17	0.90	0.28	0.72	12.57
1899	0.90	0.19	2.26	1.30	0.30	1.13	2.50	2.19	0.19	0.49	0.51	0.71	12.67
1900	0.09	0.60	0.86	11.30	1.25	2.20	1.94	0.91	0.65	0.09	0.25	1.03	21.17
1901	0.34	0.07	1.50	4.24	0.83	0.98	0.38	2.58	0.52	0.81	T	0.69	12.89
1902	0.23	0.13	1.37	1.03	4.97	2.52	0.62	2.68	1.37	0.91	0.22	0.98	17.03
1903	0.20	0.76	0.21	0.53	0.75	3.73	1.99	1.40	0.44	0.53	0.09	0.14	10.77
1904	0.03	0.07	0.06	0.71	3.08	2.70	2.69	3.09	2.37	0.62	T	0.09	15.51
1905	0.08	0.58	3.48	4.86	3.98	2.04	4.72	1.27	2.23	0.23	0.13	T	23.60
1906	0.38	0.90	2.25	4.17	0.98	1.44	3.09	2.56	2.23	0.64	0.38	0.05	19.07
Mean	0.23	0.32	1.10	2.35	2.10	1.79	2.38	2.27	0.98	0.51	0.15	0.38	14.56
Agril. Mean	0.14½	0.29	0.86	1.16½	1.42½	1.56	2.24½	2.13½	0.65	0.55	.11½	.20½	11.34
Max. for month	0.90	0.90	3.48	11.30	4.97	3.73	4.72	6.21	2.37	0.96	0.51	1.03	.....
Min. for month	0.02	0.02	0.02	0.24	0.30	0.51	0.38	0.91	0.12	0.05	T	T	.....

Established by U. S. Weather Bureau. Observer—W. Hamp.

PRECIPITATION AT YUMA, YUMA COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1891	2.35	0.50	3.63	2.90	4.21	5.23	2.98	0.75	0.64	0.05	0.13	1.25	24.62
1892	0.80	1.55	0.80	3.20	3.46	1.20	4.44	1.50	0.35	1.00	T	0.62	18.92
1893	T	0.90	0.70	0.38	2.57	1.30	2.10	0.95	T	0.40	0.41	0.55	10.26
1894	0.50	0.90	1.10	0.68	0.04	1.85	0.80	0.70	2.85	O	0.22	0.70	10.34
1895	1.20	1.70	0.50	1.10	2.76	2.73	3.22	1.77	0.55	0.10	0.60	0.10	16.33
1896	0.60	0.20	1.25	1.82	2.06	3.98	2.59	1.04	1.02	0.78	0.30	0.20	15.84
1897	0.37	0.40	2.80	0.80	1.62	4.44	1.78	2.44	T	2.55	0.10	1.00	18.30
1898	0.30	0.20	0.31	1.55	5.80	2.70	1.86	3.62	1.00	1.50	1.45	1.10	20.39
1899	1.38	0.60	1.18	0.97	1.23	3.03	2.63	2.22	0.17	0.03	0.90	0.27	14.61
1900	0.14	1.55	0.61	8.67	1.39	0.72	1.81	2.22	0.16	0.03	0.17	0.51	17.98
1901	T	1.11	2.44	3.90	0.31	3.51	1.61	6.53	0.36	0.39	T	0.57	20.73
1902	0.07	0.56	0.95	0.67	3.76	1.91	2.70	3.33	1.68	0.78	0.20	0.73	17.34
1903	0.14	1.88	0.20	0.40	1.00	2.10	2.65	3.12	0.35	0.10	0.36	0.09	12.39
1904	T	0.70	0.25	3.37	4.26	4.98	1.65	1.28	2.92	1.07	T	0.27	20.75
1905	0.31	0.13	4.47	4.27	3.64	2.16	4.45	0.73	1.91	1.64	0.05	O	23.76
1906	0.38	0.51	2.36	4.45	2.01	1.98	2.44	1.23	1.19	2.92	1.17	0.12	20.76
Means	0.53	0.84	1.47	2.45	2.51	2.74	2.48	2.09	0.95	0.83	0.38	0.50	17.77
Agril. Means	0.34	0.65	1.02½	1.68½	2.31½	2.43	2.51½	1.63½	0.59½	0.59	0.21	0.53	14.52
Max. for month	2.35	1.88	4.47	8.67	5.80	5.23	4.45	6.53	2.92	2.92	1.45	1.25	.....
Min. for month	T	0.13	0.20	0.38	0.04	0.72	0.80	0.70	T	O	T	O	.....

Established by the Colorado State Weather Bureau. Observer—Geo. W. Custer.

PRECIPITATION AT LE ROY, LOGAN COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1889	.....	.....	.....	4.40	2.09	3.38	0.36	2.56	0.83	0.37	0.60	0.10	.....
1890	0.30	0.48	0.01	2.80	1.03	1.96	0.47	1.41	T	0.98	0.48	0.01	9.93
1891	1.70	1.00	1.99	1.35	5.02	4.84	4.69	2.89	0.67	0.14	0.37	0.94	25.60
1892	0.89	2.24	0.80	4.02	2.53	1.48	3.07	1.83	0.84	1.66	0.10	0.65	20.11
1893	0.05	1.20	0.87	0.46	2.73	1.25	1.75	0.61	0.41	0.41	0.48	0.94	11.16
1894	0.35	0.46	0.95	0.98	0.17	0.75	1.16	0.47	1.06	0.08	0.26	0.65	7.34
1895	0.73	0.88	0.40	2.43	2.05	2.94	2.56	0.79	0.42	0.11	0.47	0.12	13.90
1896	0.53	0.24	1.20	1.91	2.36	3.77	1.33	0.87	0.86	0.90	0.20	0.01	14.18
1897	0.60	0.72	1.66	1.77	3.08	2.24	1.39	2.79	0.41	2.61	0.40	0.81	18.48
1898	0.38	0.26	0.67	1.07	4.60	1.31	2.83	1.13	1.27	0.54	0.65	0.27	14.95
1899	0.50	0.33	1.21	1.57	2.93	0.28	2.17	2.38	0.88	0.30	0.23	0.44	13.22
1900	0.10	0.96	0.12	7.27	2.10	0.78	1.68	0.99	0.35	0.07	0.12	0.20	14.74
1901	0.06	0.49	1.60	2.92	0.72	2.52	0.97	4.03	0.27	0.47	T	0.89	14.94
1902	0.12	0.72	1.23	1.28	3.16	1.82	0.98	3.70	3.46	0.78	0.09	0.99	18.33
1903	0.18	1.50	0.26	1.12	0.80	1.07	1.71	3.44	0.62	0.29	0.06	0.03	11.08
1904	0.10	0.26	0.35	1.99	3.97	4.39	3.46	1.17	2.96	1.55	0.04	0.05	20.29
1905	0.17	0.30	3.28	4.70	3.88	2.48	2.56	1.96	0.78	1.93	0.12	0.02	22.18
1906	0.23	0.43	1.38	4.53	1.96	1.35	1.88	2.83	2.70	2.69	1.29	0.53	21.80
Means	0.41	0.73	1.06	2.59	2.51	2.14	1.95	2.00	1.04	0.88	0.33	0.42	16.06
Agril. Mean	0.23	0.49	0.95	1.95	2.44½	1.89	1.81½	1.89½	.80½	.50½	.24½	.35½	13.58
Max. for month	1.70	2.24	3.28	7.27	5.02	4.84	4.69	4.03	3.46	2.69	1.29	0.99	.....
Min. for month	0.05	0.24	0.01	0.46	0.17	0.28	0.36	0.47	T	0.07	T	0.01	.....

Established by the Agricultural Experiment Station. Observer—Charles Green.

PRECIPITATION AT ROCKY FORD, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1889	0.36	0.12	0.67	2.12	1.75	0.75	4.50	1.28	0.26	1.68	0.77	0.04	14.30
1890	0.34	0.15	0.15	2.97	0.29	0.77	1.14	0.74	0.68	0.00	0.30	0.00	6.93
1891	1.50	0.00	1.80	0.43	3.52	2.31	0.74	0.73	1.75	0.21	0.20	1.77	14.96
1892	0.50	0.80	1.50	0.73	3.26	3.31	1.99	3.10	0.00	0.95	0.50	0.46	17.10
1893	0.02	0.58	0.80	0.25	0.70	0.40	10.26	3.20	0.30	0.25	T	0.50	16.76
1894	0.10	0.95	0.45	0.60	4.25	0.70	1.40	0.25	0.80	0.00	0.04	0.65	10.19
1895	0.27	0.65	0.07	0.35	1.90	0.52	4.87	1.80	T	0.85	0.20	0.57	12.11
1896	0.32	0.18	0.23	0.55	1.12	0.47	2.09	0.47	1.85	1.96	0.00	0.70	9.94
1897	0.75	0.37	0.20	0.44	.....	.....	.....	0.73	0.79	2.64	0.19	1.06	.....
1898	0.40	0.00	0.16	1.06	2.71	3.16	3.52	0.92	1.55	1.36	0.37	0.96	16.17
1899	0.98	0.55	0.32	0.28	0.99	0.78	7.00	2.22	1.43	0.63	2.40	0.98	18.56
1900	T	0.52	0.37	7.15	2.28	1.47	1.77	1.05	0.08	0.60	0.06	0.24	15.59
1901	0.20	0.10	1.00	2.36	1.34	0.23	1.48	0.74	0.48	0.25	0.00	0.50	8.68
1902	0.18	0.57	1.78	0.18	4.02	0.60	0.72	2.72	0.46	0.80	0.41	0.33	12.77
1903	T	1.05	0.18	0.56	0.28	3.94	0.42	0.87	T	1.62	0.26	0.22	9.40
1904	T	T	0.77	0.81	2.03	2.20	1.75	0.33	2.34	0.50	0.00	0.31	11.04
1905	0.05	0.11	2.11	4.67	2.13	1.56	1.30	0.45	1.48	0.10	0.41	0.02	14.39
1906	0.23	0.10	0.92	5.59	0.59	0.54	2.05	1.21	1.64	1.57	0.22	T	14.66
Normal	0.34	0.35	0.75	1.73	1.95	1.39	2.76	1.27	0.85	0.89	0.35	0.52	13.15
Agril. Mean	0.25	.16	.56	0.66	1.90	0.77	1.77	.90	0.64	0.72	0.21	0.48	9.02
Max.	1.50	1.05	2.11	7.15	4.25	3.94	10.26	3.20	2.34	2.64	2.40	1.77	.....
Min.	T	O	0.07	0.18	0.28	0.23	0.42	0.25	O	O	O	O	.....

Established by Agricultural Experiment Station. Observers—F. L. Watrous, 1889—August, 1892; F. A. Huntley, August, 1892 – September, 1895; P. K. Blinn, September, 1895—September, 1897; W. F. Crowley, September, 1897—March, 1898; H. H. Griffin, March, 1898—June, 1903; P. K. Blinn, June, 1903.

PRECIPITATION AT CHEYENNE WELLS, CHEYENNE COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1891	.....	.....	1.00	2.00	3.10	2.32	4.97	2.35	1.92	T	T	2.25	.....
1892	0.10	0.60	2.25	0.50	.....	3.63	2.09	4.40	T	0.45	0.20	0.96	.....
1893	0.25	T	T	.....	1.10	1.15	2.50	1.64	0.68	T	0.30	0.03	.....
1894	T	1.30	0.10	0.62	2.36	0.48	1.99	1.03	0.14	0.14	T	0.55	8.41
1895	0.67	0.27	0.26	1.67	1.49	3.00	6.38	1.22	T	0.21	0.30	0.42	15.79
1896	0.45	T	0.71	3.41	2.28	3.03	2.27	3.07	0.84	0.78	T	0.60	17.44
1897	0.35	0.30	1.58	1.30	1.44	2.22	4.19	3.24	0.92	2.73	0.10	0.20	18.18
1898	0.03	0.00	0.61	1.10	5.56	3.95	2.09	1.33	2.00	0.48	0.50	0.48	18.13
1899	0.47	0.36	0.39	0.03	2.88	1.89	3.67	0.55	.78	T	2.49	0.55	14.06
1900	0.03	0.67	0.56	9.95	0.80	2.47	2.02	0.30	1.31	0.22	T	0.18	18.51
1901	0.15	0.38	0.71	4.02	1.18	0.90	2.63	2.59	1.12	0.49	0.02	0.25	14.44
1902	T	0.25	1.32	0.78	3.12	2.53	1.42	6.06	0.20	1.32	O	0.75	18.35
1903	0.34	0.79	0.23	0.94	3.71	2.63	1.87	1.89	T	T	0.75	0.13	13.28
1904	T	T	0.11	1.59	2.51	4.78	3.39	4.89	4.26	0.99	0.00	0.29	22.81
1905	0.14	0.35	2.00	5.16	2.13	2.58	2.02	1.12	2.41	0.40	0.09	T	18.31
1906	0.21	0.24	0.89	3.77	1.24	3.00	4.26	2.39	2.36	0.90	0.26	T	19.46
Means	0.19	0.35	0.83	2.45	2.33	2.54	2.98	2.38	1.18	0.57	0.30	0.48	16.58
Agril. Means	0.14	0.27	0.71	1.59	2.28	2.55½	2.29¾	2.12	0.88	0.42½	0.06	0.35¼	13.79
Max. for month	0.67	1.30	2.25	9.95	5.56	4.78	6.38	6.06	4.26	2.73	2.49	2.25	.....
Min. for month	T	O	T	0.03	0.80	0.48	1.42	0.30	T	T	O	T	.....

Established by the Agricultural Experiment Station. Observers—J. B. Robertson, 1891—April, 1896; J. E. Payne, April, 1896—October, 1901; L. M. Parker, October, 1901—June, 1902; J. B. Robertson, June, 1902.

MONTHLY RECORD OF PRECIPITATION, 1907

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Denver	0.46	0.33	0.54	2.91	2.93	1.15	1.52	0.23	0.74	0.17	0.40	0.45	11.83
Fort Collins	0.23	0.36	0.69	2.80	2.44	0.44	2.28	1.27	0.58	0.08	0.44	0.03	11.64
Wray	0.12	0.02	0.24	0.94	2.17	1.53	3.39	3.80	1.27	0.03	0.14	0.58	14.23
Hamps	0.15	T	0.27	2.38	1.85	0.65	2.59	1.06	0.74	0.02	0.20	0.65	10.56
Yuma	0.28	0.02	0.33	0.94	1.43	2.44	3.44	2.58	1.44	0.04	0.24	0.35	13.53
LeRoy	0.12	0.05	0.25	0.97	2.85	2.67	2.24	4.19	1.88	T	0.66	0.69	16.57
Cheyenne Wells	T	T	0.13	0.72	1.10	2.86	1.98	0.95	1.28	0.25	0.25	0.20	9.72
Rocky Ford	T	T	0.00	1.84	1.85	0.69	4.96	0.78	0.33	0.88	2.00	0.26	13.59

Press of the Fort Collins (Colo.) Express.

Bulletin 124 July, 1907

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

COLORADO FODDERS

AN EXAMINATION INTO THEIR COMPOSITION AND COMPARATIVE VALUES

BY

W. P. HEADDEN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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INTRODUCTORY

In the following pages, I have endeavored to state my results fully enough to enable the reader to clearly understand my interpretation and have, at the same time, given the data so fully that he may draw his own conclusions, and judge whether mine are justified or not.

In this work I have had no predecessor to follow, so far as I know. The study of the chemical composition of timothy hay presented by the Pennsylvania Experiment Station is quite different from the present work, and I have not taken up timothy hay in detail, for reasons given in the proper place. The only attempt to determine the digestibility of the different extracts of any fodder that I remember to have seen mention of, was made in France. I do not recall the fodder or fodders studied or the scope of the investigation.

I do not know that any similar attempt to study the calorific value of the various portions of the fodders and the relative amounts of heat furnished by them, their coefficients of appropriation, has been made.

I have given the analytical data as fully as possible, including the ordinary fodder analyses of both the fodders and the feces, similarly their ultimate analysis, the analysis of their ashes, and what I have, for the purpose of this bulletin, designated as their proximate analysis. By proximate analysis, I mean the division of the fodder into different portions by means of the following solvents: 80 per cent. alcohol, cold water, hot water with subsequent addition of malt extract, 1 per cent. hydric chlorid, 1 per cent. sodic hydrate and chlorin in the presence of water, with subsequent washing with water, boiling sodic hydrate, 1 per cent. solution, and sulfurous acid. The portion which resisted these successive treatments has been designated as residue or cellulose.

The heat or energy, given in small calories, removed by these successive treatments, and the percentage of this heat value appropriated by the animals have been studied in detail for three of the fodders, alfalfa, corn fodder and the saltbush, *Atriplex argentea*.

The distribution of nitrogen and also that of the furfurol, in these various extracts has been determined, but no attempt has been made to distinguish between arabinose and xylose, all being calculated as xylan. Determinations of mucic acid were made on these fodders, and the sugar obtained by treating the alfalfa hay with 1 per cent. hydric chlorid has been considered as being derived from galactan, which is also probably present, according to our results, in some of the other fodders.

The reducing power of the sodic hydrate extract has been indicated as xylan with an interrogation point, because it is very probably not derived from xylan. The quantity of this sugar is altogether insignificant, except in the case of the saltbush, in which it is relatively large.

COLORADO FODDERS

AN EXAMINATION INTO THEIR COMPOSITION AND COMPARATIVE VALUES

By W. P. HEADDEN

SEC. 1. In Bulletin No. 39 of this Station, I endeavored to study alfalfa, clover, pea-vine, and our native hay, but particularly alfalfa hay with special regard to the carbohydrates, including under this term the crude fibre and nitrogen-free extract.

§2. In Bulletin No. 93 I have given the results of experiments on the digestibility of alfalfa, timothy and native hay, also on the saltbush, *Atriplex argentea*, corn fodder and sorghum.

§3. In Bulletin 93, I followed the beaten path and gave the coefficients of digestion as obtained for the usual groups, proteids, crude fibre, nitrogen-free extract, etc. In the present bulletin, I shall take up the same hays and fodders treated of in Bulletin No. 93, but I shall consider them from the standpoint of Bulletin No. 39, following the same general method that I used in that work, but extending it very considerably.

§4. While it might be of scientific interest to study the ether extract, it is not a very important factor in the study of the coarse fodders presented in this bulletin as it, at most, amounts to only a small percentage of these fodders, usually to less than three per cent., and these three per cent. are composed of fats, waxes, coloring and other matters, none of which are involved in the questions which form the object of this study.

§5. I have discovered no good reason for taking up the extract by absolute alcohol, so I began the work by extraction with boiling 80 per cent. alcohol, which removes coloring matter, sugars and extractives. We found that extraction with four portions of alcohol, boiling each portion 20 minutes, was quite sufficient to exhaust the sample. We used 10 grams of hay and 450 c. c. of alcohol. The amount extracted by the fourth portion of alcohol amounted to only 0.30 of one per cent. of the air dried hay.

§6. We attempted to evaporate the extracts to dryness and weigh them, but in checking against the weight of the dried residue we found a difference of about two per cent., *i. e.*, the dried extracts were about this much too low. After considerable work to see if we could not obtain better agreement between the direct weighings of the extracts and the weight of the remaining hay, we decided to take the loss of weight as indicated by the residual hay as the weight of the material extracted. Had we been trying to obtain results to be expressed in terms of the extract, this method would of course not be admissable, but as we have expressed all results in terms of

the air dried hay or fodder, this method has the patent advantage of giving every percentage upon a basis which can be easily duplicated within quite narrow limits which we found would be attended with considerable difficulty if we used the weight of the extracts obtained, as each one showed a deficit for which we could not account. The weight of the residual portion of the hay seemed, furthermore, to be less subject to change, debarring the absorption of moisture which is comparatively easily guarded against, than that of the extract.

§7. As already stated, the boiling, 80 per cent. alcohol extracted the hays readily and even the first portion removed practically all of the coloring matters which, particularly in the case of alfalfa, was large and difficult to remove from the extract.

§8. It was not possible for us to prosecute any examination of these coloring matters, but it was necessary that we should remove them completely from the solution before we could proceed to test for sugars. The matter of decolorizing these solutions proved to be a difficult one. I first tried the effect of adding potassic aluminate and the precipitation of the aluminic hydrate by passing carbon-dioxid through the solution. My idea was that the precipitating aluminic hydrate might carry down all of the coloring matter, this, however, did not prove to be the case and the filtrate from the $Al_2 (O H)_6$ had a bright yellow-red color. We pursued this a little further but the results, while interesting in themselves, did not advance the work in hand.

§9. Though I desired to avoid the use of basic acetate of lead, it proved to be the most effective agent in removing the yellow coloring matter, the filtrate however, was green and worked badly with the Fehling's solution, yielding a flocculent precipitate which may have contained cuprous oxid, it probably did, but the precipitate was essentially something else. We found that the addition of cupric sulfate removed the green coloring matter completely, yielding a colorless solution, provided no excess of the cupric sulfate had been added. The use of the basic acetate of lead and cupric sulfate worked well.

In Bulletin 39, I recorded the observation that the reducing power of such extracts are greatly diminished by the addition of basic acetate of lead but that I failed to detect any sugar in the precipitate.

§10. In the present work, it was imperative to establish one fact, *i. e.*, that the combined use of the lead and copper salts did not in any way affect the quantity of sugar, sucrose, present either by removing it with the precipitate or causing its inversion.

§11. In order to establish this point, several portions of the extract which had been made up to a given volume, after the alco-

hol had been distilled off, were taken and a weighed portion of pure sugar added to some of them. All the portions were then decolorized by the use of lead acetate, sodic sulfate and cupric sulfate, always added in this order, the precipitate filtered off and washed, the excess of copper removed by H_2S and the H_2S expelled by passing $C O_2$ through the solution, the two last operations were quite unnecessary, but I thought that it could happen that I might wish to remove the copper and subsequently the $H_2 S$ in this manner and so I included them in this test. The results showed that the sugar was wholly unchanged both in character and quantity by these operations. This method was therefore adopted, as the substances which exert a reducing action upon the Fehling solution and are removed by these precipitants are neither glucose nor saccharose, the presence and quantity of which I wished to establish. The other substances are of course included in the extract yielded by the hay.

§12. The total reducing power of the cold water extract after inversion by heating with hydric chlorid is attributed to the presence of gums. It is probable that this class of bodies is the source of the reducing sugars produced, but the amount of sugar or gum present in this extract is so small that it is no matter of great moment by what name we designate it.

§13. The reducing power of the hot water extract after the action of malt extract has been expressed as starch. The total amount extracted by the cold and hot water respectively is much less than one would expect, but it must be borne in mind that the hay or fodder had been previously extracted, we may say exhausted, with boiling 80 per cent. alcohol. The amounts extracted by these media are also much more nearly equal than one would expect, the cold water in a few instances actually dissolving more than the hot water and malt extract.

§14. The hydric chlorid used was a one per cent solution. The extraction of the hay or fodder with this reagent gave us more trouble than all other determinations combined. All of the work recorded in this bulletin was done in duplicate and if our results did not agree, the work was repeated until we found how to proceed in order to obtain concordant results.

§15. It is true that agreement of results may not be conclusive proof that the method used is the best one, or even that the work has been correctly done, but their disagreement, when obtained by the same method and under similar conditions, is conclusive of one of two things, either that the operations have been interrupted at different stages or that the method is wholly inadequate and an end point is not attainable. We found that the different hays and fodders resisted the action of this one per cent.

solution of hydric chlorid in very different degrees. In those cases in which the amount of xylan was high, we found that boiling for thirty minutes did not suffice for the accomplishment of our purpose, *i. e.*, to carry the action of the hydric chlorid to an end.

§16. In some fodders and dungs we found it necessary to boil them two, and in a few cases, even three times with separate portions of the acid in order to obtain results which agreed reasonably well. We found, too, that the inversion of this extract was much more difficult than of any of the others,—it being necessary to use ten c. c. conc. hydric chlorid and to digest in the water bath for two hours: this means at our altitude, a temperature of about 85° to possibly 90° C. in the solution, even though the water in the bath is kept boiling briskly. We found that this quantity of acid and time gave us the highest results, measured in terms of the reducing power, and usually a good agreement between the duplicates.

§17. The sodic hydrate used was also a one per cent. solution. The reducing power of this extract, after inversion, was, as a rule, very small. We observed in this connection that the reducing power of this extract was frequently higher in those cases in which we found it difficult to complete the extraction with hydrochloric acid than in others. I interpret this variation as suggesting that the small amount of reducing sugars found in the sodic hydrate extract may belong to the hydric chlorid extract rather than indicate the presence of a hexose sugar.

§18. The residue left after treatment with sodic hydrate was washed free from Na O H, dried, etc. It was next moistened with water and spread out on the inner surface of a small flask which was connected with a chlorin apparatus and allowed to stand for an hour after the flask had become entirely filled with the gas. It was then washed, boiled with dilute Na O H and subsequently with H_2 S O_3 and the residue finally dried and weighed as cellulose. The action of chlorin, etc., did not produce any reducing sugars, at least there were none present in the filtrate.

§19. In Bulletin 93, we have recorded our results in determining the coefficients of digestion of the groups, substances usually taken cognizance of in our ordinary fodder analyses, *i. e.*, Dry Matter, Ash, Fat, Protein and Nitrogen-free Extract; in the present bulletin, I intend to present the results of these same experiments using a different series of groups, or to give the coefficients of digestion for the alcoholic extract, cold water extract, hot water extract, one per cent. hydic chlorid extract, one per cent. sodic hydrate extract, chlorin extract, and lastly, of the cellulose or that portion which persistently resists the action of these reagents. In addition to the preceding coefficients, I shall give the coefficients of digestion

of those groups which yield the reducing sugars under the conditions already indicated and also of those complexes which yield furfurol on distillation with twelve per cent. hydric chlorid solution, but as I have sought to determine the distribution of these groups and complexes in the different extracts it will be quite impossible to bring the results within the compass of a single table. I will, therefore, be compelled to make two statements of the results which will supplement each other, but which cannot in any sense replace or contradict each other. I will also give the calorific values of the hays, dungs and of the residues yielded by the respective treatments in the case of the alfalfa, corn fodder and saltbush, these being the best for our purposes; timothy hay, sorghum and native hay not suiting so well. Our native hay is a mixture of such character that results obtained with it would be of little value except in a very general sense.

§20. The hays and fodders used in this work are the same as those used in Bulletin 93, in fact, that work was done largely for the purpose of obtaining data according to the conventional methods for the particular samples used n this study. The hays and fodders were intentionally chosen to represent both legumes and grasses grown and preserved under our Colorado conditions.

§21. The distribution of the nitrogen in these extracts appears from the results of the work recorded in Bulletin 39, to present some points of more than usual interest. For instance, we found that 27 per cent. of the total nitrogen in alfalfa hay was removed by extraction with boiling 80 per cent. alcohol and subsequent treatment with cold water. This nitrogen may have been contained in the coloring matters to a greater extent than in some other hays, but it is certainly not all contained in the chlorophyll and it is not probable that it is amid nitrogen for it exceeded the amount that we had previously found in alfalfa hay in this form. The advisability of making these nitrogen determinations is further indicated by the persistence with which some nitrogen remains with the crude fibre after boiling with 1.25 per cent. sodic hydrate solution. In the work referred to we found that 4.51 per cent. of the total nitrogen in alfalfa hay remained in the crude fibre, when it had been prepared in the usual way by boiling for thirty minutes with the 1.25 per cent. sodic hydrate solution. We shall see that this was not a chance result, but indicated a general fact and we shall further see that this statement is correct for the hays and fodders studied in this bulletin.

§22. The distribution of the ash in these various extracts has been wholly disregarded.

§23. The analysis of the dungs present, of course, the same questions that the conventional methods do in regard to the com-

pounds in which the nitrogen is contained, *i. e.*, whether it is contained in undigested portions of fodder or in fecal matter. The results obtained in this work in regard to the nitrogen, are open to the same questions that those of our ordinary analysis and possibly to even more serious ones, for we divide it up into six or seven portions instead of presenting it as the common constituent of a single class without raising any further questions.

§24. The samples of hays fed were of course the same throughout the experiments, so that one analysis represents the whole of any fodder fed and no questions can arise relative to this; concerning the orts and dungs, however, there might be a question. In Bulletin 93, we calculated the coefficient of digestion for each individual animal and took the average of the coefficients so found as the coefficients of digestion of the several hays and fodders. Owing to the tediousness of the work, we followed a different procedure in this case, *i. e.*, we made composite samples of the dungs, by taking the same aliquot part of the dung voided by the different sheep in each 24 hours during the time of the experiment and combining them into a composite sample. The sample of orts was prepared in a similar manner.

ANALYTICAL DATA—ALFALFA HAY.

§25. The following analyses have been brought together in order to present, succinctly as possible, all that our analyses tell us about the fodders and their digestibility.

The average coefficients of digestibility found for this particular alfalfa hay were for the dry matter 62.08, ash 57.67, fat 29.86, protein 72.54, fibre 49.93, and for the nitrogen-free extract 72.89. The general facts presented by the data concerning alfalfa pertain to all of the other fodders.

TABLE I.

ALFALFA HAY.

FODDER ANALYSIS.

ALFALFA HAY		FECES OF SHEEP NO. 6	
Moisture	7.75	Moisture	6.82
Ash	11.77	Ash	12.15
Ether Extract	1.62	Ether extract	3.12
Proteids	15.03	Proteids	10.86
Crude Fibre	30.28	Crude Fibre	40.34
Nitrogen-free extract	33.55	Nitrogen-free extract	26.83
	100.00		100.00

TABLE II.

ASH ANALYSIS.

ALFALFA		CORRESPONDING FECES*	
Percentage of ash in hay..	11.77	Percentage of ash in Feces..	12.15
Sand	8.524	Sand	12.682
Silicic acid	6.844	Silicic acid	8.676
Sulfuric acid	6.269	Sulfuric acid	2.037
Phosphoric acid	3.158	Phosphoric acid	7.629
Carbonic acid	17.399	Carbonic acid	21.081
Chlorin	6.801	Chlorin	0.666
Potassic oxid	27.271	Potassic oxid	3.207
Sodic oxid	4.287	Sodic oxid	1.733
Calcic oxid	14.736	Calcic oxid	29.590
Magnesic oxid	4.006	Magnesic oxid	7.719
Ferric oxid	1.428	Ferric oxid	1.440
Aluminic oxid	0.288	Aluminic oxid	0.879
Manganic oxid (br)	0.180	Manganic oxid (br)	0.330
Ignition	0.341	Ignition	2.481
	101.532		100.150
Oxygen, Equiv. to chlorin..	1.532	Oxygen Equiv. to Chlorin..	.150
	100.000		100.000

TABLE III.

ULTIMATE ANALYSIS.

ALFALFA HAY		CORRESPONDING FECES	
Carbon	43.517	Carbon	45.769
Hydrogen	5.868	Hydrogen	5.494
Nitrogen	2.405	Nitrogen	1.738
Sulfur	0.342	Sulfur	0.189
Chlorin	0.819	Chlorin	0.123
Phosphorus	0.162	Phosphorus	0.405
Potassium	2.665	Potassium	0.323
Sodium	0.374	Sodium	0.156
Calcium	1.239	Calcium	2.569
Magnesium	0.286	Magnesium	0.566
Oxygen plus the remaining ash constituents	42.323	Oxygen plus the remaining ash constituents	42.668
	100.000		100.000

§26. For good, clean, alfalfa hay the ratio of thoroughly air-dried feces to the hay consumed is one to two and seven-tenths or five and one-half pounds of hay eaten will correspond to just a trifle more than two pounds of feces.

§27. The silicic acid has not been taken into account in the preceding analyses because it is very uncertain how much of it is due to fluxing of the minerals constituting the dust and sand found in the ash.

§28. These data show the extent to which the potash is taken up by the animal system, the feces being very poor in this substance

*Sheep No. 6.

while the opposite is the case with the phosphoric acid and lime.

§29. The ultimate composition of the hay and feces does not appear to differ as much as one might expect, so far as the carbon, hydrogen and oxygen are concerned but an ultimate analysis of a mixture of such complex substances as we have to do with in these cases could scarcely be expected to show decided differences, still it shows that 61.6 per cent. of the carbon in the hay consumed, is digested. The feces show a higher percentage of carbon than the hay, which may indicate that the compounds having the higher carbon content are less readily attacked than those with less. These analyses further show that the hydrogen, nitrogen, sulfur, chlorin and the alkalies, particularly potassium, are very largely taken up from the fodder, while the calcium, magnesium and prosphorus are voided with the feces to a very large extent. This is strikingly the case in regard to phosphorus, for according to the ratio given for the hay consumed to the feces voided, 5½ : 2, it results that of 892 parts of phosphorus ingested by sheep, 810 parts are voided with the feces, which indicates a coefficient of digestion of 10.3 per cent. for the phosphorus consumed, which is quite small, averaging 1.31 grams per day, of which only 10.3 per cent. or 0.131 gram was appropriated by the animal. The potassium stands in strong contrast to this with a coefficient of 95.6 per cent. The following pages present some further considerations, based on different data.

§30. The following analyses are of an entirely different character and present a study of the same hay from another standpoint.

§31. The statement of the analyses is given so fully that no further explanation is needed in this place.

TABLE IV.

ANALYSIS OF ALFALFA HAY.

The percentages given in following analyses are computed on air-dried hay.

	I	II	Av.
	Per cent.	Per cent.	Per cent.
Eighty per cent. alcohol extracted...	27.177	27.818	27.50
Cold water, 24 hours digestion, extracted	8.535	8.785	8.66
Hot water and malt extracted... ...	4.790	3.950	4.37
Hydric chlorid, 1 per cent. sol., extracted	12.487	11.968	12.23
Sodic hydrate, 1 per cent. sol., extracted	15.341	17.046	16.19
Chlorin, etc., extracted.....	8.372	9.155	8.76
Cellulose, residue	23.298	21.278	22.29
			100.00

SUGARS IN THE EXTRACTS.

Glucose in the alcoholic extract.....	1.280	1.280	1.28
Sucrose in the alcoholic extract.....	0.942	0.942	0.94
Gums, etc., in cold water extract.....	0.833	0.770	0.80
Starch in hot water and malt extract	1.267	1.260	1.26
Galactan, inverted by 1 per cent. HCl	2.960	2.770	2.87
Reducing power of the 1 per cent. Na O H extract	0.320	0.378	0.35

The average of two determinations of galactan made according to the official method was 2.89 per cent. It seems probable that the reducing power of the one per cent. HCl extract of alfalfa hay is wholly due to galactan, but only partly so in corn fodder and in native hay.

TABLE V.

ANALYSIS OF ALFALFA ORTS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	26.532	26.276	26.40
Cold water, 24 hrs. extracted.....	8.580	8.559	8.57
Hot water and malt extracted.....	3.970	4.256	4.11
Hydric chlorid, 1 per cent. sol. extracted	11.687	11.863	11.78
Sodic hydrate, 1 per cent. sol. extracted	16.637	14.885	15.76
Treatment with chlorin, etc., extracted	8.519	9.853	9.19
Cellulose remaining	24.074	24.308	24.19
			100.00

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract.....	1.25	1.25	1.25
Sucrose in alcoholic extract.....	1.67	1.45	1.56
Gums in cold water extract.....	0.47	0.38	0.43
Starch in hot water extract.....	0.94	0.97	0.96
Galactan	3.96	4.45	4.21
Reducing power of sodic hydrate extract	0.70	0.97	0.80

TABLE VI.

ANALYSIS OF DUNG OF SHEEP FED ON ALFALFA HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted...	19.107	19.363	19.24
Cold water, 24 hrs. digestion, extracted	4.912	4.872	4.89
Hot water and malt extracted.....	3.635	3.349	3.49
Hydric chlorid, 1 per cent. sol., extracted	13.580	12.457	13.02
Sodic hydrate, 1 per cent. sol., extracted	12.796	15.166	13.98
Treatment with chlorin, etc., extracted	19.711	15.091	17.40
Cellulose remaining.....	26.259	29.702	27.98
			100.00

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract.....	None	None	None
Sucrose in alcoholic extract.....	None	None	None
Gums in cold water extract.....	0.40	0.32	0.4
Starch in hot water and malt extract	0.21	0.21	0.2
Galactan in hydric chlorid extract..	1.37	0.98	1.1
Reducing power of sodic hydrate extract	**1.57**	**1.30**	**1.4**

TABLE VII.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF ALFALFA HAY.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef
Total alcoholic extract.....	3671.4	260.5	3410.9	890.9	2520.0	73.8
Total cold water extract....	1177.2	84.6	1092.6	228.4	846.2	78.8
Total hot water malt extract	583.6	40.6	543.0	161.6	381.4	70.2
Total hydrochloric acid ext..	1630.9	116.2	1514.7	602.9	911.8	60.2
Total sodic hydrate extract	2161.6	155.5	2006.1	647.3	1358.8	67.7
Total chlorin etc., extract..	1179.6	99.7	1079.9	805.7	274.2	25.3
Total cellulose	2876.1	238.7	2737.4	1295.6	1441.8	52.6
Total dry mater	13351.4	986.8	12364.6	4630.4	7734.2	62.5

§32. The average coefficient of digestion of the dry matte in this hay obtained by the usual method was found to be 62.0 It is given as 63.95 on page 23 of Bulletin 93, but this is a mistak It should be 62.05.

TABLE VIII.

COEFFICIENTS OF DIGESTION OF THE CARBOHYDRATES IN ALFALF HAY AS INDICATED BY THE SUGARS OBTAINED FROM THE VARIOUS EXTRACTS.

	Fed.	Orts	Consumed.	Voided.	Digested.	Co
In alcoholic extract, glucose	170.9	12.3	158.6	00.0	158.6	100.
In alcoholic extract, sucrose	125.5	15.4	110.1	00.0	110.1	100.
In cold water ext., gums, etc.	106.8	4.2	102.6	19.4	83.2	81.
In hot water malt ext. starch	164.2	9.5	154.7	9.7	145.0	93.
In 1 p. c. hydrochloric acid extract, Galactan	381.9	41.5	340.4	54.6	285.8	83.
					Excess	
In 1 p. c. sodic hydrate extract, (Hexose?).....	46.7	7.9	38.8	66.7	—27.9	
In chlorin, etc., extract, this extract showed no reducing power.						
Cellulose residue after chlorin, etc., treatment						52

§33. In the preceding table, it will be noticed that the amou of reducing sugar found in the one per cent. sodic hydrate extra for the dung exceeds the amount found for the extract of the h by a very considerable amount, 71.91 per cent.

§34. At first, I thought that the small amount of reducing sugar found in the solution obtained by boiling the hays or fodders with the one per cent. solution of sodium hydrate, was due to imperfect extraction by the hydrochloric acid or perhaps owed its origin to complexes which had been attacked by the hydrochloric acid and thereby rendered soluble in the sodic hydrate, but the relatively large amount extracted from the dung by this reagent, for we find the same excessive amount in the dungs corresponding to each of the six fodders suggests that it is not an accident due to the incompleteness of the action of the hydrochloric acid but that it is due rather to the presence of some compound which effectively resists the action of the hydrochloric acid but which is soluble in sodic hydrate and is either hydrolized by this agent or is made susceptible to the action of the hydrochloric acid subsequently used as the hydrolytic agent. If this were the indication of even a duplicate analysis of the dung corresponding to one of the fodders, one would certainly be justified in doubting its sufficiency as the basis of any inference, but it is not simply an accidental agreement of duplicate results, obtained in the analysis of a single sample of dung, but is the result of duplicates made on the dungs corresponding to six fodders which differ materially from one another. This difference between the fodders and the corresponding dungs may be due to changes produced in the fodders during their passage through the alimentary tract or to excrementitious matter proper. It seems probable that it is the latter.

§35. In regard to the reducing sugar produced by the action of the dilute hydric chlorid, I have in the case of the alfalfa attributed it to the presence of galactan because the agreement between the determination of mucic acid and the reducing power of the inverted solution was good; in the other cases I have used the term xylan as a general term for the pentosans hydrolized by the dilute hydic chlorid. Mucic acid determinations made on the samples of corn fodder and native hay indicate the presence of some galactan but its quantity is much less than the total reducing power, so it is probable that both galactan and xylan are present, but I have used the term xylan in all cases except in that of alfalfa.

§36. The total reducing power of the extract yielded to one per cent. sodic hydrate solution by alfalfa hay corresponds to 38.8 grams, whereas the reducing power of the extract yielded by the feces under the same treatment corresponds to 66.7 grams or 1.7 times as much. Whatever the source of this reducing power may be it is evidently much more abundant in the extract of the dung voided than the hay consumed. It is probable that the excessive reducing power of the sodic hydrate extract of the dung over that of the hay is due to its action on fecal matter and not on the undigested rem-

nants of the hay. This excessive reducng power of the sodic hydrate extract of the dung over that of the hay is not an accident or attributable to inaccurate work, for it is uniformly the case with all of the dungs corresponding to the six fodders used.

§37. This result is similar to that obtained for the coefficient of digestion for the ether extract in the first series of experiments made on the digestion of alfalfa hay in which the amount of ether extract obtained from the feces was more than double the amount consumed. In this case, I attributed this excess to the solubility of fecal matter only after I had canvassed every other apparent explanation, because it was observed in one series of experiments only and was not observed in the case of any other fodder than the alfalfa. If other experimenters have met with such striking results, they have rejected them, as I was tempted to do, for the simple reason that others have done this work in the same way and the recorded results agreed in showing that my results were, to say the least, very exceptional. In this case, however, I have a series of six very different fodders and they agree in showing that, in this respect, there is a marked difference between the fodders and the feces of the animals feeding on them.

PENTOSANS.

§38. There are certain complexes existing in the fodders which when subjected to distillation with hydrochloric acid yield furfurol. In this work, I have considered this furfurol as such and have endeavored to determine its coefficients of digestibility for the various extracts.

§39. In Bulletin 39, we found the total amount of furfurol calculated as xylan yielded by alfalfa, to range for the first cutting from 9.44 to 14.42 per cent.; for the second cutting, hay grown at Rocky Ford, 12.34 per cent. The average found for the cutting of 1894 was 11.44 per cent.; for 1896, 11.48 and the average for all of the determinations made on samples covering the two years was 11.48 per cent.

§40. The furfurol found in the hay used in these experiments, was 8.16 or 13.38 xylan; in the orts 9.95 per cent.; in the feces 12.69 per cent. xylan. There were fed 1786.4 grams of xylan. The orts contained 98.19 grams and the feces 587.6; accordingly 1100.6 grams of xylan had been digested or the coefficient of digestion for the total xylan was 65.12. The corresponding amounts of furfurol are, in the hay fed 1089.5 grams, in the orts 59.9 grams, in the feces 318.9 grams, digestion coefficient 65.18.

§41. We determined the furfurol in the residue after the extraction and not in the evaporated extract for the same reason that we determined the extracts themselves by difference, *i. e.*, be-

cause we found a deficiency of about two per cent. on evaporating the extracts to dryness.

TABLE IX.

FURFUROL FOUND IN ALFALFA HAY, ORTS AND THE FECES AND IN THE RESIDUE AFTER TREATMENT WITH THE VARIOUS SOLVENTS.

	Alfalfa hay	Alfalfa orts	Feces
	Per cent.	Per cent.	Per cent.
Original Hay	8.160	6.068	7.742
Residue after 80 per cent. alcohol	7.078	5.367	7.638
Residue after cold water	6.494	5.322	Same
Residue after hot water	5.736	5.122	6.940
Residue after 1% hydric chlorid	4.220	3.765	Same
Residue after 1 per cent. sodic hydrate	2.586	2.131	3.778
Residue after chlorin, etc.	1.919	2.080	1.394

TABLE X.

THE COEFFICIENTS OF DIGESTION FOR FURFUROL IN THE VARIOUS EXTRACTS OF ALFALFA HAY.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
Furfurol in alcoholic extract	144.50	6.90	137.60	4.80	132.80	96.51
Furfurol in cold water ext	77.98	0.40	77.58	0.00	77.58	100.00
Furfurol in hot water ext...	101.20	2.00	99.20	32.30	66.90	67.44
Furfurol in hydrochloric acid extract	202.40	13.40	189.00	0.00	189.00	100.00
Furfurol in sodic hydrate ext	218.20	16.10	202.10	146.90	55.20	27 81
Furfurol in chlorin, etc., ext	89.05	10.50	88.55	110.39	—21.84	....
Furfurol in residue, cellulose	256.20	20.50	235.70	64.54	171.16	72.62
	1089.53	59.80	1029.73	358.90	670.83	65.15

§42. The treatment with boiling one per cent. hydric chlorid aims at the removal of easily hydrolized substances which might yield fufurol on distillation with the stronger, 12 per cent., acid. This treatment removes considerable quantities of furfurol yielding substances from the hay which apears to be wholly digestible for we find none in the feces. On the other hand, the hydric chlorid, one per cent. solution, removes hydrolyzable substances from the feces corresponding to 1.03 per cent. of galactan. The one per cent. hydric chlorid solution removes from the hay 1.52 per cent. of furfurol and contains reducing sugars equal to 3.01 per cent. of galactan which is probably the source of the reducing sugar, as the hay yields when treated with hydric nitrate, sp. gr. 1.15, according to the official method, mucic acid corresponding to 2.86 per cent, galactan, so it seems probable that both pentose and hexose sugars are represented in the composition of the hay.

§43. I have elsewhere noted the fact that in making duplicate determinations of this reducing power, it was difficult to obtain agreement in the results and that in some fodders, we had to repeat the treatment as many as three times to get even a fair agreement. I interpret this as indicating a radical difference in the character of the compounds in the different fodders which are attacked by this reagent.

METHOXYL GROUP.

§44. At the time this work was done no tests, so far as I knew, had been made to prove whether this group existed in ordinary plants. Recently, however, it has been shown that certain woods, not known to contain quinine or related alkaloids, yield methyl iodid on distillation with strong hydriodic acid showing the presence of compounds containing the methoxyl group.

§45. The presence of aromatic compounds in the urine of herbivores and the fact of the general prevalence of alkaloidal compounds in plants, some of which contain the methoxyl group, suggested the probability of the presence of this group in the fodders. I accordingly attempted its determination, using the original Zeisel method.

§46. I did not determine this group in the orts, for both the amount of the orts and the percentage of this group present being small, no great error is introduced by the omission, besides my chief object was to establish the presence or absence of the group in the case of each fodder and obtain, if possible, an idea of the amount of these compounds appropriated by the animal, an approximate coefficient of digestion. I did not hope to accomplish more than this.

§47. The duplicate, and in some cases, triplicate determinations, agreed fairly well. The largest difference in twelve sets of duplicates, including also some triplicates, was less than one-half of one per cent. We checked our work using quinine, a commercial article, obtaining a fair agreement in our determination, but the results were a little lower than required by theory, which leads me to infer that my results are too low rather than too high.

METHOXYL GROUP IN ALFALFA HAY FED AND FECES VOIDED.

	I	II	Av.
	Per cent.	Per cent.	Per cent.
Alfalfa Hay	1.18	1.23	1.21
Dung, sheep fed alfalfa	2.46	2.31	2.39

§48. The hay consumed was 12,364.8 grams containing 148.38 grams of the methoxyl group; the feces weighed 4,630.5 grams and contained 110.7 grams of methoxyl, giving us a digestion coefficient of 25.42 for this group.

§49. I will anticipate a general result which will be evident when the determinations of this group in all the samples have been given, *i. e.*, that it is present in hays made from grasses and leguminous plants, also in corn fodder, sorghum and the saltbush, *Atriplex argentea,* being most abundant in the last named plant; further that the percentage of this group present in the dung is approximately twice that in the hay or fodder, except in the case of the saltbush in which it is only one and one-half times as much as in the saltbush itself.

AMID NITROGEN IN ALFALFA HAY.

§50. In calculating the proteids we have multiplied the total nitrogen by 6.25 consequently our product is too high, as more or less of the nitrogen is present in the form of amids, compounds containing a higher percentage of nitrogen and, consequently, having a factor less than 6.25, if for example, the nitrogen were present as asparagine, its factor would be 4.7.

§51. In the following statement I have given the proteid equivalent to the amids. I have made no attempt to divide the nitrogen compounds further than into the two groups, proteids and amids.

§52. The amid nitrogen found in samples of alfalfa hay cut at half bloom is as follows, 0.372, 0.350, 0.614; average is 0.444 which is rather far removed from the maximum which is, however, the highest found in eleven samples. The amid nitrogen found in the alfalfa hay used in this series of experiments was 0.446 agreeing very well with the average found for the other samples cut in half bloom.

§53. The proteids in the alfalfa hay fed, corresponding to the amid nitrogen, amounted to 372.11 grams; in the orts 34.66 grams; consumed 337.45 grams; voided 62.23 grams; digested 275.22 grams, from which we obtain 81.55 for the coefficient of digestion for the amid nitrogen.

THE PROTEIDS REMOVED BY THE VARIOUS SOLVENTS AND THEIR COEFFICIENT OF DIGESTION.

§54. As the boiling 80 per cent alcohol removed practically all the coloring matters from the hays, I deemed it advisable to extract them with anhydrous ether and determine the nitrogen removed in this manner. I have assumed that the nitrogen thus removed is principally contained in the coloring matters. For this extraction, I use 30 grams of air-dried hay, macerated it with 150 c. c. of ether for 16 hours, and then subjected it to extraction in a soxhlet extractor for ten hours. Our air-dried hay carries from 5 to 7 per cent. of moisture. I have repeatedly compared the results

obtained by extracting air-dried hay with those obtained from the same hay dried in the water oven, also in hydrogen and have seldom found so large a variation that it was of any practical significance. The maximum amount of nitrogen found in the ether extracts of the three hays, alfalfa, timothy and native hay, was contained in the extract from the native hay which contained 0.007 per cent.; that from the timothy contained nitrogen equal to 0.0033 per cent. and that from the alfalfa 0.0032 per cent., calculated on the air-dried hay. The largest one of which corresponds to less than 0.05 per cent. of proteids.

§55. The weight of the dried ether extracts from these three hays varied from 0.5 to 0.75 grams from which it is evident that the coloring matters in these hays must be poor in nitrogen.

§56. If we assume that the nitrogen in these ether extracts is present as proteid nitrogen there would be in that from the native hay approximately 0.05 per cent., a quantity which we can disregard in ordinary work but this is twice as large as the amount found in either of the other two hays.

§57. In regard to the sulfur in alfalfa, the question has frequently suggested itself whether it belonged mostly to the proteids or whether it was present in combination, as sulfuric oxid, probably forming calcic sulfate. Wishing to answer this question in connection with the proteids, we digested a quantity of hay with dilute hydrochloric acid and washed it thoroughly. The sulfuric acid was then precipitated as baric sulfate and weighed after purification. The sulfur present in the hay as sulfuric acid amounted to 0.68 per cent. The total sulfuric acid estimated from that found in the ash, allowing a loss of two per cent. in incineration, was 0.94, leaving sulfur equivalent to 0.26 per cent. of sulfuric acid as proteid sulfur.

§58. Corn fodder treated in the same manner did not show the presence of any sulfuric acid and the sulfur is probably present as proteid sulfur and not in the form of sulfates.

§59. In the following statements, the proteids, respectively the nitrogen calculated as proteids, soluble in 80 per cent. alcohol included the nitrogen soluble in the ether which, as we have just seen, is a very small amount, not more than 0.05 per cent.

§60. The coefficients of digestion for the proteids contained in the various extracts of alfalfa hay:—

TABLE XI.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS DISSOLVED OUT OF ALFALFA HAY BY THE VARIOUS SOLVENTS.*

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
Proteids soluble in boiling 80 per cent. alcohol.....	640.88	46.47	594.41	108.82	485.59	81.69
Proteids soluble in cold water	90.79	26.05	64.74	42.60	22.14	34.20
Proteids soluble in hot water and malt	134.85	9.87	124.98	68.53	56.45	45.17
Proteids soluble in 1 per ct. hydric chlorid	126.84	1.18	125.66	50.47	75.19	59.84
Proteids soluble in 1 per ct. sodic hydrate	937.28	75.58	851.70	154.20	697.50	81.89
Proteids soluble in chlorin, sodic hydrate and sulfurous acid	45.40	5.92	39.48	50.01	(—10.53)	———
Proteids remaining in the cellulose	17.36	1.28	16.08	13.43	2.65	16.48
			1817.05	488.06	1328.99	72.92

§61. The coefficients of digestion found for the proteids by the usual method, and given on page 23, Bulletin 93, are for sheep No. 4, 73.68 per cent.; sheep No. 5, 73.58 per cent.; sheep No. 6, 70.36 per cent.; the average is 72.54 per cent. The coefficient found by calculating it from the sum of the respective extracts of the hay, and dung is 72.92 per cent. actually in better agreement with the two higher coefficients found for sheep No. 4 and 5, than the result obtained for sheep No. 6.

§62. This coefficient, 72.92, would be slightly changed if we made a correction for the amid nitrogen found, but this is nearly correct for the total nitrogen. This statement applies to all the coefficients for the proteids.

THE CALORIFIC VALUE OF ALFALFA HAY.

§63. The calorific value of the hay was determined by means of the bomb calorimeter. By hay, we mean the air-dried hay as fed to the sheep; it contained 7.75 per cent. moisture and 11.77 per cent. ash. Its calorific value was 4,050 calories,† and that of the dung was 4,300 calories. The total hay consumed by the three sheep was 12,364.8 grams. The air-dried feces weighed 4,630.5 grams, which shows that the animals used 62.30 per cent. of the total heat value of the hay. I have assumed that the orts did not

*I have used the term proteids in this place to signify the product of the nitrogen multiplied by 6.25. This remark applies to all of the fodders. Everyone knows that this is conventional and does not mean that there is only one class of nitrogenous compounds present.

†The Calorie used throughout this Bulletin is the small calorie.

differ from the hay because I was compelled to, due to the fact that the orts had all been used for other determinations. The total amount of the orts was small.

§64. The total heat consumed as dry matter by the three sheep was 49,585,495 calories; the total heat value of the dry matter contained in the feces was 18,620,832 calories; there were accordingly 30,955,663 calories appropriated by the sheep, equivalent to 62.43 per cent. of the energy value of the hay. By appropriated I mean that the energy was taken up and either stored in the body or eliminated in some other way than through the alimentary tract as undigested food. The energy escaping in the exhalations, as well as that contained in the urine, is included in the term appropriated.

TABLE XII.

The dry hay gave the following extracts and residue:

	Per cent.
Soluble in boiling 80 per cent. alcohol	21.40
Soluble in cold water	9.38
Soluble in hot water and malt	4.73
Soluble in boiling 1 per cent. hydric chlorid	13.35
Soluble in boiling 1 per cent. sodic hydrate	17.54
Soluble in chlorin, etc.	9.45
Residue—cellulose	24.15
	100.00

The distribution of the ash in these extracts was not determined.

TABLE XIII.

THE CALORIFIC VALUE OF THE HAY AND OF THE SEVERAL RESIDUES.

The calorific value of the dry hay	4363 calories
The calorific value of residue after extraction with 80 per cent. alcohol	4270 calories
The calorific value of residue after extraction with cold and hot water	4517 calories
The calorific value of residue after extraction with 1 per cent. hydric chlorid	4759 calories
The calorific value of residue after extraction with 1 per cent. sodic hydrate	4603 calories
The calorific value of residue after extraction with chlorin, etc.,	4210 calories

TABLE XIV.

Calories removed from alfalfa hay by the successive treatments.

One gram of hay yields to boiling 80 per cent. alcohol	1007 calories
One gram of hay yields to cold and hot water with malt	443 calories
One gram of hay yields to boiling 1 per cent. hydric chlorid	480 calories
One gram of hay yields to boiling 1 per cent. sodic hydrate	887 calories
One gram of hay yields to treatment with chlorin, etc.	527 calories
One gram of hay yields a residue, cellulose	1017 calories
	4363 calories

TABLE XV.

CALORIFIC VALUE OF THE RESPECTIVE EXTRACTS OF ALFALFA HAY.

One gram of the alcoholic extract gives	4706 calories
One gram of the cold water, hot water and malt extract gives	3140 calories
One gram of the 1 per cent. hydric chlorid extract gives	3596 calories
One gram of the 1 per cent. sodic hydrate extract gives	5063 calories
One gram of the chlorin, etc. extract gives	5598 calories
One gram of the residue, cellulose, gives	4210 calories

TABLE XVI.

THE DRY FECES (ALFALFA HAY) GAVE THE FOLLOWING EXTRACTS AND RESIDUE.

	Per cent.
Soluble in boiling 80 per cent. alcohol	13.405
Soluble in cold water	5.243
Soluble in hot water and malt	3.742
Soluble in boiling 1 per cent. hydric chlorid	13.961
Soluble in boiling 1 per cent. sodic hydrate	14.980
Soluble in chlorin, sodic hydrate and sulfurous acid	18.657
Residue, cellulose	30.012
	100.00

TABLE XVII.

THE CALORIFIC VALUE OF THE FECES (ALFALFA) AND THE VARIOUS RESIDUES.

The calorific value of the dry feces	4525 calories
The calorific value of the residue after extraction with 80 per cent. alcohol	4339 calories
The calorific of the residue after extraction with cold and hot water and malt	4373 calories
The calorific value of the residue after extraction with 1 per cent. hydric chlorid	4441 calories
The calorific value of the residue after extraction with 1 per sodic hydrate	4886 calories
The calorific value of the residue after extraction with chlorin, etc.	4294 calories

TABLE XVIII.

THE CALORIFIC VALUE REMOVED FROM THE FECES (ALFALFA HAY) BY THE SUCCESSIVE TREATMENTS.

One gram of dry feces yields to boiling 80 per cent alcohol	769 calories
One gram of dry feces yields to cold and hot water with aid of malt	362 calories
One gram of dry feces yields to boiling 1 per cent. hydric chlorid	567 calories
One gram of dry feces yields to boiling 1 per cent. sodic hydrate	449 calories
One gram of dry feces yields to chlorin, etc.	1090 calories
One gram of dry feces yields residue, cellulose	1288 calories

TABLE XIX.

THE CALORIFIC VALUE OF THE VARIOUS EXTRACTS OF THE FECES (ALFALFA HAY)

One gram of the alcoholic extract gives	5739 calories
One gram of the cold and hot water, etc., extract gives	4123 calories
One gram of the boiling 1 per cent. hydric chlorid gives	4061 calories
One gram of the boiling 1 per cent. sodic hydrate gives	2397 calories
One gram of the chlorin, etc., extract gives	5842 calories
One gram of the residue, cellulose, gives	4294 calories

TABLE XX.

COEFFICIENTS OF DIGESTION FOR THE HEAT VALUES OF THE VARIOUS EXTRACTS OF ALFALFA HAY.

	Heat Units Consumed	Heat Units Voided	Heat Units Appro.	Coefficient
Alcoholic extract	15,852,166	5,113,449	10,738,717	67.75
Aqueous extract*	5,074,240	1,599,724	3,474,516	68.51
One per cent. hydric chlorid extract	5,447,940	2,448,783	2,999,157	54.75
One per cent. sodic hydrate extract	10,156,378	1,938,059	8,218,319	80.92
Chlorin, etc., extract	6,046,840	4,708,652	1,337,188	24.03
Residue or cellulose	11,522,770	5,570,208	5,952,562	51.66

§65. The coefficients of digestibility of the heat values of the various extracts show the same general features exhibited by the preceding tables, showing , in particular, the high value of the portion soluble in 80 per cent. alcohol which furnishes the largest portion by weight of dry substance digested—over one-third of the total nitrogen digested and one-third of the total heat units appropriated. The sodic hydrate extract furnished, in the case of alfalfa the largest amount of nitrogen, one half more than the alcoholic extract, less dry matter than either the cellulose or the alcoholic extract and one-fifth less heat than the alcoholic extract.

§66. The values of the extracts, measured by the heat furnished, stand as follows for alfalfa: Alcoholic extract, 11 millions heat units; sodic hydrate extract, 8 millions; the insoluble portion of the fodder, the cellulose, 6 millions of heat units.

§67. This order does not hold good for the other fodders examined in this manner. The alcoholic extract and the cellulose constitute two of the three most important portions of the fodder, but the hydric chlorid extract stands above the sodic hydrate as a source of heat in the corn fodder.

TIMOTHY HAY.

§68. The timothy hay used was the best that we could obtain in the open market and was grown in the mountains.

§69. Though the hay appeared to be of excellent quality, the sheep did not do well on it, one sheep gained one-half pound in five

*The aqueous extract includes all that was dissolved out by cold water, 24 hours digestion, boiling with water for one hour and subsequently treating with malt extract.

days, the other two together lost one and a half pounds, leaving a net loss of one pound for the three sheep in five days. This is in strong contrast with the results obtained with the alfalfa and corn fodder. The sheep fed alfalfa all gained. The total gain for the three sheep was nine pounds in five days; those fed on corn fodder also all gained, the total gain in five days being three and one-half pounds, so we have 9 and 3½ pounds gain respectively for the alfalfa and corn fodder, against a net loss of one pound for the timothy hay. The coefficient of digestion for the dry matter in the alfalfa hay found by the ordinary method of determining it was 62.05, and by considering the extracts individually it was 62.55. In the case of the timothy hay, we obtained in the ordinary manner 51.03, in the manner here pursued 51.10, an excellent agreement in both cases with a difference of 11 per cent. in these coefficients, that of the alfalfa being the higer. The sheep consumed, however, 11,265 grams of dry matter, as alfalfa hay, leaving almost no orts and only 8,223 grams of dry matter as timothy hay, leaving 4,233 grams of orts.

TABLE XXI.

ANALYTICAL DATA. TIMOTHY HAY.

Proximate Analysis.

TIMOTHY HAY		CORRESPONDING FECES Sheep No. 1	
Moisture	6.49	Moisture	6.79
Ash	9.37	Ash	7.84
Ether extract	2.99	Ether extract	2.28
Proteids	5.62	Proteids	5.92
Crude fibre	31.54	Crude fibre	37.26
Nitrogen-free extract	43.99	Nitrogen-free extract	39.91
	100.00		100.00

TABLE XXII.

ANALYSIS OF THE ASH.

TIMOTHY HAY		CORRESPONDING FECES	
Sand	26.249	Sand	43.943
Silicic acid	11.506	Silicic acid	9.126
Sulfuric acid	3.033	Sulfuric acid	1.515
Phosphoric acid	4.239	Phosphoric acid	11.428
Carbonic acid	5.390	Carbonic acid	1.259
Chlorin	7.177	Chlorin	0.798
Potassic oxid	30.118	Potassic oxid	10.721
Sodic oxid	0.146	Sodic oxid	1.122
Calcic oxid	5.586	Calcic oxid	11.981
Magnesic oxid	2.685	Magnesic oxid	3.868
Ferric oxid	0.540	Ferric oxid and Aluminic oxid	1.171
Alumnic oxid	0.176	Manganic oxid	0.189
Manganic oxid	0.370	Ignition	3.000
Ignition	(4.357)		
	101.617		100.121
Oxygen equivalent to Chlorin	1.617	Oxygen equivalent to chlorin	.180
	100.000		99.941

TABLE XXIII.

ULTIMATE ANALYSIS.

TIMOTHY HAY		CORRESPONDING FECES	
Carbon	44.241	Carbon	46.362
Hydrogen	5.832	Hydrogen	6.186
Nitrogen	0.892	Nitrogen	0.954
Sulfur	0.104	Sulfur	0.143
Chlorin	0.506	Chlorin	0.133
Ash	9.370	Ash	7.840
Oxygen (approx.)	39.045	Oxygen (approx.)	38.382
	100.000		100.000

§70. The ash in this analysis, of course, represents the thoroughly oxidized, non-combustible portion of the plant containing a considerable portion of both the chlorin and sulfur. The chlorin and sulfur given above are the quantities contained in the air-dried hay as obtained by direct determination. The percentage of ash as given is too high by the amount of the chlorin and sulfur retained which is from 92 to 98 per cent. of the total sulfur and chlorin respectively, and also by the oxygen which the ash constituents may have taken up. The percentage of oxygen is, for these reasons, retention of chlorin and sulfur and the possible absorption of oxygen by the ash constituents, too low, for which reason, I have designated it as approximate only.

TABLE XXIV.

ANALYSIS OF TIMOTHY HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted	21.307	20.931	21.12
Cold water in 24 hrs. extracted	6.858	7.039	6.95
Hot water extracted	3.000	2.968	2.98
Hydric chlorid, 1 per cent. sol. extracted	19.740	20.717	20.23
Sodic hydrate, 1 per cent. sol. extracted	17.108	16.997	17.05
Chlorin, etc., extracted	5.548	5.872	5.71
Cellulose remaining	26.439	25.476	25.96
			100.00
SUGARS IN THE EXTRACTS			
Glucose in alcoholic extract	1.16	1.44	1.30
Sucrose in alcoholic extract	2.83	2.83	2.83
Gum in cold water extract	3.12	3.12	3.12
Starch in hot water extract	None	None	None
Reducing power calculated as Xylan in hydric chlorid extract	15.77	Lost	15.77
Reducing power calculated as Xylan in sodic hydrate extract	0.83		0.83

TABLE XXV.

ANALYSIS OF ORTS OF TIMOTHY HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted..	22.952	23.194	23.07
Cold water in 24 hrs. extracted.....	4.034	4.447	4.24
Hot water extracted	2.895	2.461	2.68
Hydric chlorid, 1 per cent. sol. extracted	19.552	19.826	19.68
Sodic hydrate, 1 per cent. sol. extracted	Lost	14.680	14.68
Chlorin, etc., extracted		8.530	8.53
Cellulose remaining		27.120	27.12
			100.000

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract.....	2.48	2.43	2.46
Sucrose in alcoholic extract.....	3.29	3.37	3.33
Gum in cold water extract.....	1.82	2.03	1.93
Starch in hot water extract.....	None	None	None
Xylan in hydric chlorid extract.....	14.32	15.39	14.86
Xylan in sodic hydrate extract.....	Lost	1.31	1.31

TABLE XXVI.

ANALYSIS OF FECES OF SHEEP FED ON TIMOTHY HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted..	16.592	15.512	16.05
Cold water in 24 hrs. extracted.....	2.840	2.818	2.83
Hot water extracted	3.255	3.288	3.27
Hydric chlorid, 1 per cent. sol. extracted	16.230	16.802	16.52
Sodic hydrate, 1 per cent. sol. extracted	16.893	19.226	18.06
Chlorin, etc., extracted	14.272	11.563	12.92
Cellulose remaining	29.918	30.792	30.35
			100.00

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract.....	None	None	None
Sucrose in alcoholic extract.....	None	None	None
Gum in cold water extract.....	0.20	0.0	0.10
Starch in hot water extract.....	None	None	None
Xylan in hydric chlorid extract.....	7.91	9.44	8.68
Xylan in sodic hydrate extract.....	2.25	2.06	2.15

TABLE XXVII.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF TIMOTHY HAY.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract.....	3813.0	1036.5	1776.5	691.4	1085.1	61.08
Total cold water extract....	925.6	196.5	815.1	121.9	694.2	85.06
Total hot water and malt ext.	397.8	120.4	277.4	140.9	136.5	49.21
Total hydrochloric acid 1% extract	2694.4	884.2	1810.2	711.6	1098.6	60.69
Total sodic hydrate (1 per per cent.) extract.....	2270.9	659.8	1511.1	777.9	733.2	48.52
					Excess	
Total chlorin, etc., extract..	760.6	383.0	377.6	556.5	—173.9	——
Total cellulose, residue, ...	3457.7	1218.3	2239.3	1307.4	931.9	41.61
Total	13320.0	4492.7	8808.2	4307.6	4500.6	51.10

Average coefficient of digestion for dry matter given page 29, Bulletin No. 93, 51.03.

TABLE XXVIII.

COEFFICIENTS OF DIGESTION FOR THE CARBOHYDRATES IN TIMOTHY HAY AS INDICATED BY THE SUGARS OBTAINED FROM THE VARIOUS EXTRACTS.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
In the alcoholic extract:						
Glucose	173.2	110.5	62.7	0.0	6.27	100.00
Sucrose	377.0	149.6	227.4	0.0	227.4	100.00
In the cold water extract, Gums, etc.	415.6	86.7	328.9	4.3	324.6	98.69
In the hot water and malt extract, (starch)	0.0	0.0	0.0	0.0	0.0	——
In the 1 per cent. hydrochloric acid (Xylan) extract ...	2100.6	667.6	1433.0	373.9	1059.1	72.23
In the 1 per cent. sodic hydrate (Xylan) extract	110.5	58.9	51.6	92.6	Excess 41.0	——

§71. The furfurol in timothy hay was found to be 12.17 per cent. and there was accordingly 1,621.0 grams fed. The orts contained 11.60 per cent. equal to 521.2 grams and the feces contained 12.73 per cent., equal to 548.4 grams. This gives us 50.12 per cent. for the coefficient of digestion of the furfurol.

§72. I have used the furfurol instead of the complexes yielding it as we know quite certainly that there are probably several compounds present which may yield furfurol. Our coefficient, 50.12, shows no more than that one-half of the furfurol has been digested. If the complexes from which this is derived yield the same amounts of furfurol and are broken down with equal readiness, in the alimentary tract of the animal and by the distillation with the twelve per cent. acid, we would be justified in assum-

ing that one-half of the furfurol yielding substances are available as food for the ruminant. This is probably not far from the facts in the case, but it will be seen from the following table that we have very good reasons for doubting whether the complexes are equally attacked as we assume in making this statement.

TABLE XXIX.

FURFUROL IN THE VARIOUS EXTRACTS OF TIMOTHY HAY AND COEFFICIENTS OF DIGESTION.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Alcohol	86.6	42.7	43.7	13.4	30.5	69.47
Cold water	122.7	17.5	105.2	30.5	74.7	71.07
Hot water	26.6	9.0	17.6	34.5	(—16.9)	———
Hydric Chlorid	542.7	186.9	355.8	263.1	92.7	32.80
Sodic hydrate	456.8	151.0	305.8	270.5	35.3	11.54
Clorin	129.2	39.1	90.1	1.3	88.8	98.54
Cellulose	271.7	74.6	197.1	98.2	98.9	50.12
			1115.5	711.2	404.3	36.24

§73. The results in this table are unsatisfactory, but we repeated a number of the determinations and found no error. The discrepancy between the coefficient found by summing up the amounts in the individual extracts of the hay, orts and dung and that found by determining the furfurol in the hay, orts and dung themselves is altogether too great, but the amount digested in either case is comparatively small and large differences result from comparatively small errors in the work. The general coefficient found was 50.12.

COEFFICIENT OF DIGESTION OF THE METHOXYL GROUP IN TIMOTHY HAY.

§74. The orts, as in the case of the alfalfa, have been considered as containing the same percentage of methoxyl as the hay, which is probably not correct, but this error can be neglected as the difficulties of the determination do not permit of great accuracy at the best. The hay consumed contained 124.20 grams; there was voided 103.70 grams; digested 20.5 grams, or 16.50 per cent.

DIGESTIBILITY OF THE AMIDS IN TIMOTHY HAY.

§75. The amid nitrogen found in the timothy hay used, corresponded to 0.99 per cent. of proteids, or 0.168 per cent. nitrogen and that found for the orts was almost identical, 0.994 per cent.; in the feces we found none. According to this the amid nitrogen is wholly digestible.

§76. This result is aparently not in accord with the results given under the next caption, but we found no amid nitrogen in the

feces of sheep fed on timothy hay, native hay, corn fodder or saltbush, that is to say, we found no nitrogen in these samples which was not precipitated by cupric hydrate.

TABLE XXX.

COEFFICIENTS OF DIGESTION OF THE PROTEIDS IN THE VARIOUS EXTRACTS OF TIMOTHY HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Proteids soluble in 80% alcohol	187.81	85.04	152.77	24.12	128.65	82.30
Proteids soluble in cold and hot water	82.58	41.78	40.80	53.41	(—12.61)	....
Proteids soluble in 1% hydric chlorid	98.57	33.25	65.32	42.65	22.67	34.71
Proteids soluble in 1% sodic hydrate	350.31	126.69	223.62	92.61	186.01	58.59
Proteids soluble in chlorin	13.23	10.78	2.45	37.48	(—35.03)	....
Proteids in residue, cellulose	9.32	2.70	6.62	6.89	(—0.27)	....
Total	741.82	250.24	491.58	257.16	234.42	47.69

The general coefficients of digestibility found for the three individual sheep were 47.73, 41.06 and 41.27. Average 43.35.

CALORIES CONSUMED AND VOIDED.

§77. We find the calorific value of dry timothy hay to be 4,414 and 4,417, an average of 4,415 plus; the orts gave 4,392 and the feces 4,709 calories.

§78. The dry matter fed contained 54,979,995 calories; the orts contained 18,586,944 calories and the feces 18,986,688 calories, which indicates the use of 47.83 per cent. of the heat energy of the fodder, or 17,406,363 calories.

§79. This timothy hay proved to be a poor fodder for sheep when fed alone. Two of the sheep lost weight and the third one gained one-half pound between the two weighings.

§80. We did not carry our calorimetric work further with timothy hay for the reason that this hay has been made the subject of study by others. Quite an exhaustive study of it is to be found in the Report of the Pennsylvania State College for the year 1903 and 1904.

NATIVE HAY.

§81. This hay is made up of a mixture of grasses and represents a fodder which is prized by many as an excellent one. The mixture of grasses varies greatly even in hay from the same farm. The results obtained in experiments with this hay are therefore applicable to other samples of it in a general way only, and it is for

this reason that we have not determined the heat value of the residues, obtained by extracting the hay with the various solvents adopted in this work.

TABLE XXXI.

ANALYTICAL DATA FOR NATIVE HAY.

NATIVE HAY		CORRESPONDING FECES Sheep No. 6.	
Moisture	5.13	Moisture	5.96
Ash	10.64	Ash	12.41
Ether extract	3.13	Ether extract	5.02
Proteids	6.98	Proteids	5.48
Crude fibre	31.38	Crude fibre	29.29
Nitrogen-free extract	42.74	Nitrogen-free extract	41.84
	100.00		100.00

TABLE XXXII.

ANALYSIS OF ASH IN NATIVE HAY.

ASH OF NATIVE HAY		ASH OF CORRESPONDING FECES	
Carbon	Heavy trace	Carbon	
Sand	3.375		
Silicic acid	54.736	Sand and Silicic acid	73.913
Sulfuric acid	1.521	Sulfuric acid	0.884
Phosphoric acid	2.133	Phosphoric acid	3.156
Carbonic acid	4.871	Carbonic acid	2.849
Chlorin	4.878	Chlorin	0.347
Potassic oxid	17.786	Potassic oxid	5.373
Sodic oxid	0.640	Sodic oxid	0.845
Calcic oxid	6.180	Calcic oxid	7.087
Magnesic oxid	2.016	Magnesic oxid	1.477
Ferric oxid	0.685	Ferric oxid	0.280
Aluminic oxid	0.273	Aluminic oxid	0.266
Manganic oxid	0.132	Manganic oxid	0.210
Ignition	1.719	Ignition	(2.891)
	100.945		100.078
Oxygen equivalent to chlorin	1.099	Oxygen equivalent to chlorin	0.078
	99.846		100.000

TABLE XXXIII.

ULTIMATE ANALYSIS OF NATIVE HAY.

NATIVE HAY		CORRESPONDING FECES	
Carbon	43.814	Carbon	45.328
Hydrogen	5.792	Hydrogen	5.935
Nitrogen	0.996	Nitrogen	0.919
Sulfur	0.116	Sulfur	0.109
Chlorin	0.673	Chlorin	0.073
Ash	10.640	Ash	12.410
Oxygen, (approx.)	27.969	Oxygen, (approx.)	25.226
	100.000		100.000

§82. The ash analysis of this hay shows a very high percentage of silicic acid. It is a well known fact that the ash of some of the grasses contain a large amount of silica, but this ash is as high or even a little higher than the superior limit usually found. This ash, when evaporated to dryness with hydric chlorid and subsequently treated with water, leaves a felt-like mass of silicic acid which is made up of quadrangular plates with irregular margins. If a stem of this hay be treated with hydric nitrate and potassic chlorate, to destroy the tissues and remove the soluble salts, and then be burned, one can obtain a beautiful skeleton of silica showing the outlines of the epidermal cells and the stomata. The total ash amounts to a little over one-tenth of the weight of the hay, and over one-half of this is silicic acid. The skeleton thus obtained seems to show that the stem is completely sheathed in a siliceous covering. The leaves also furnish skeletons, but these differ considerably in their details from the skeletons of the stems. The silica, however, seems quite abundant in the leaves, almost as much so as in the stems. This blue stem feels harsh to the touch, not so much so, perhaps, as the sedges, but the skeletal silica seems to be even more abundant in the blue stem than in the sedges.

§83. The coefficient of digestion found for this ash, 42.52, seems to be very high, too high in fact, but the separation of the silicic acid and sand in the ash of the feces was particularly difficult.

TABLE XXXIV.

PROXIMATE ANALYSIS OF NATIVE HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	21.469	21.537	21.50
Cold water, in 24 hrs., extracted.....	5.917	5.813	5.87
Hot water extracted	2.975	2.726	2.85
Hydric chlorid, 1 per cent. sol. extracted	20.544	21.049	20.80
Sodic hydrate, 1 per cent. sol., extracted	16.485	16.816	16.64
Chlorin, etc., extracted	5.586	4.868	5.23
Cellulose, residue	27.024	27.191	27.11
			100.00
SUGARS IN THE EXTRACTS			
Glucose in alcoholic extract	1.38*	1.38	1.38
Sucrose in alcoholic extract	2.89	2.89	2.89
Gums in cold water extract	2.50	2.50	2.50
Starch in hot water extract	1.10	1.12	1.11
Reducing power expressed as Xylan, hydric chlorid extract.....	12.53	12.53	12.53
Reducing power expressed as Xylan, sodic hydrate extract.....	Trace	Trace	Trace

*We experienced more trouble than usual with this sample, so I have used averages of several pairs. The results are only approximately correct.

TABLE XXXV.

ANALYSIS OF ORTS OF NATIVE HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	23.377	24.256	23.82
Cold water, in 24 hrs., extracted.....	5.899	5.197	5.55
Hot water extracted	2.999	2.701	2.85
Hydric chlorid, 1 per cent. sol. extracted	20.062	20.066	20.06
Sodic hydrate, 1 per cent. sol., extracted	16.917	16.922	16.92
Chlorin, etc., extracted	7.359	7.772	7.57
Cellulose, residue	23.387	23.086	23.23
			100.00
SUGARS IN THE EXTRACTS			
Glucose in alcoholic extract	1.54*		1.54
Sucrose in alcoholic extract	1.72		1.72
Gums in cold water extract	2.83		2.83
Starch in hot water extract	1.12		1.12
Xylan in hydric chlorid extract.....	12.53		12.53
Xylan(?) in sodic hydrate extract....	1.28		1.28

TABLE XXXVI.

DUNG OF SHEEP FED ON NATIVE HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	17.430	17.928	17.68
Cold water, in 24 hrs., extracted.....	3.090	3.251	3.17
Hot water extracted	3.351	3.880	3.62
Hydric chlorid, 1 per cent. sol. extracted	15.538	15,230	15.38
Sodic hydrate, 1 per cent. sol., extracted	23.011	22.387	22.70
Chlorin, etc., extracted	9.288	9.078	9.18
Cellulose, residue	28.292	28.246	28.27
			100.00
SUGARS IN THE EXTRACTS			
Glucose in alcoholic extract	None	None	None
Sucrose in alcoholic extract	None	None	None
Gums, etc., in cold water extract.....	Trace	Trace	Trace
Starch in hot water extract	None	None	None
Xylan in hydric chlorid extract.....	10.13	9.07	9.60
Xylan(?) in sodic hydrate extract...	2.22	2.28	2.25

*This analysis, like that of the hay, was exceedingly unsatisfactory, though done in duplicate and repeated by two different operators.

TABLE XXXVII.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF NATIVE HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract.....	2834.1	618.7	2215.4	918.2	1297.2	58.55
Total cold water extract...	773.8	144.2	629.6	164.6	465.0	73.86
Total hot water and malt extract	375.7	74.0	301.7	188.0	113.7	37.69
Total hydric chlorid extract	2741.9	521.0	2220.9	798.7	1422.2	64.04
Total sodic hydrate extract	2193.5	439.5	1754.0	1178.9	575.1	32.79
Total chlorin, etc., extract.	689.4	196.6	492.8	476.7	16.1	3.28
Residue, cellulose	3573.6	603.3	2970.3	1468.1	1502.2	50.57
	13182.0	2597.3	10584.7	5193.2	5391.5	50.94

Average coefficient given for dry matter, Bulletin 93, page 32, 50.53.

TABLE XXXVIII.

COEFFICIENT OF DIGESTION FOR THE CARBOHYDRATES IN NATIVE HAYS, AS INDICATED BY THE SUGARS OBTAINED FROM THE VARIOUS EXTRACTS.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose in alcohol extract.	181.9	40.0	141.9	0.0	141.9	100.00
Sucrose in alcohol extract..	381.0	44.7	336.3	0.0	336.3	100.00
Gums in cold water extract	329.6	73.5	256.1	Trace	256.1	100.00
Starch in hot water and Malt extract	146.3	29.1	117.2	0.0	117.2	100.00
Xylan in hydric chlorid ext.	1651.7	325.4	1326.3	496.3	830.0	62.58
Xylan(?) in sodic hydrate extract	147.6	29.1	118.5	116.8	1.7	1.43
	2838.1	541.8	2296.3	613.1	1683.2	73.30

TABLE XXXIX.

COEFFICIENTS OF DIGESTION OF THE FURFUROL IN THE VARIOUS EXTRACTS OF NATIVE HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Alcohol	107.6	51.3	56.3	21.4	34.9	61.91
Cold water ..... / Hot water	87.3	40.2	47.1	43.9	3.2	6.79
Hydric chlorid, 1% Sol.....	711.6	102.7	608.9	240.7	368.2	44.04
Sodic hydrate, 1% Sol.....	359.7	51.6	308.1	178.2	129.9	42.16
Chlorin	126.9	17.6	109.3	121.9	-12.6	....
Cellulose	269.0	49.9	219.1	54.9	164.2	74.94
	1662.1	313.3	1348.8	661.0	687.8	50.99

§84. The coefficient of digestion found by calculating the furfurol in the hay fed, subtracting that contained in the orts, etc.,

is 50.63, which is in good agreement with that obtained by taking the sum of the separate extracts.

TABLE XL.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS IN THE VARIOUS EXTRACTS OF NATIVE HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Proteids soluble in 80% alcohol	230.69	47.53	183.16	66.47	116.69	63.71
Proteids soluble in cold water and malt and hot water and malt	69.86	18.96	50.90	35.83	15.07	29.61
Proteids soluble in 1% hydric chlorid	97.55	23.12	74.43	27.52	46.91	63.03
Proteids soluble in 1% sodic hydrate	383.60	59.48	324.12	129.82	194.30	58.58
Proteids soluble in chlorin,	29.00	4.93	24.07	27.01	—2.94	——
Proteids remaining in the cellulose	10.55	2.08	8.47	11.95	—3.48	——
	821.25	156.10	665.15	298.60	366.55	55.11

§85. The average coefficients of digestion found for the proteids in native hay, using three sheep, was 62.33, Colorado Experiment Station Bulletin No. 93, page 32.

HEAT VALUE OF NATIVE HAY.

§86. The energy was found to be equal to 4,349 calories for the dry hay and that of the dried feces was found to be 4,579 calories. The calorific value of the fodder consumed was 46,034,165 calories, that of the feces 23,778,747 calories; accordingly the animals appropriated 22,255,418 calories, or 48.34 per cent. of the total energy.

§87. The heat values or energy of the different extracts were not determined because, as stated in the description of this hay, it is made up of a mixture of grasses, sedges, etc., which varies so that this sample cannot be taken as representative except in a general way.

AMID NITROGEN.

§88. The proteids corresponding to the amid nitrogen in native hay amounted to 0.513 per cent., but we were unable to find any in the feces, consequently we infer that they were wholly digestible. The better way to put this is that the quantity of amid nitrogen is so small that, as a fodder constituent, it is wholly negligible.

METHOXYL GROUP IN NATIVE HAY.

§89. This group is present in the hay to the extent of 1.795 per cent., and in the feces to the extent of 2.764 per cent. The hay

consumed was 10,585 grams, and the feces voided 5,193 grams, which gives us a coefficient of 23.47 for the digestibility of this group in the hay.

§90. The results obtained in feeding this hay were fairly good, the net result being a gain of three and one-half pounds during the five days between the weighings. The dry matter voided in the feces was almost one half of that consumed, and the coefficients of digestion were found to be comparatively low. This hay, designated as native hay, commands a high price and is held in high esteem, particularly for horses.

§91. In this experiment no grain or other fodder than the hay was fed. I wished to study the hay and not to determine an advantageous ration, of which it should be a part.

§92. If we compare the data furnished by the results obtained with alfalfa and those obtained in the case of the native hay, we observe very great differences. In the first place, the alfalfa is evidently a more palatable food to sheep than this hay or timothy. There was fed of the native hay, 13,182 grams, the sheep left 2,596 grams; of the alfalfa, 13,350 grams, of which 987 grams were left; of the timothy, 13,320 grams, of which 4,493 grams were left. These hays were all cut in order to induce the sheep to eat it up clean as possible. Sheep prefer, for instance, the leaves of alfalfa to the stems, and I wished to force them to eat the stems as well as the leaves.

TABLE XLI.

THE AMOUNT OF THE RESPECTIVE EXTRACTS DIGESTED AND THEIR COEFFICIENTS OF DIGESTION.

	Native Hay		Alfalfa Hay	
	Grams digested	Coefficients	Grams digested	Coefficients
Alcohol, 80%	1297.	58.55	2520.	68.64
Cold water	465.	73.86	846.	78.89
Hot water	114.	37.69	381.	70.24
Hydric chlorid	1422.	64.04	912.	60.20
Sodic hydrate	575.	32.79	1359.	67.72
Chlorin	16.	3.28	274.	25.39
Cellulose	1502.	50.57	1442.	52.67

§93. In regard to the relative amounts of the extracted matter digested and corresponding coefficients, we observe that much larger amounts of those substances dissolved out by the eighty per cent. alcohol, cold and hot water, the latter with addition of malt extract, were digested in the case of the alfalfa than in that of the native hay, and the coefficients of digestion are materially higher. The reverse is the case with those substances dissolved out by the one per cent. hydric chlorid, the quantity digested, as well as the

coefficient of digestion, being higher in the case of native hay than in that of the alfalfa. The amount of digestible matter removed from alfalfa by the one per cent. solution of sodic hydrate is greater, about 2⅓ times, than that removed from the native hay. The matter removed by chlorin, etc., is neither considerable in quantity, nor does it appear to be very digestible. The amounts of cellulose digested were approximately the same in the two cases, as are also the coefficients of digestion.

§94. The most important fact to be kept in mind in this comparison is that the same sheep when fed these hays made a uniform gain of three pounds in five days on the alfalfa, or a net gain of nine pounds, whereas two gained one-half pound each and one two and a half pounds in five days, a net gain of three and one-half pounds, when fed the native hay. It may be futile to seek an explanation of these results in the analytical data, but it is the purpose of this bulletin to present the latter as fully as we are at present able to, in order to see whether this may in any way be possible. An examination of the amounts of the various extracts digested and their coefficients of digestion would lead us, possibly justly so, to attach great importance to the alcoholic and sodic hydrate extracts, especially as the latter solvent is supposed to remove the principal portion of the nitrogenous compounds to which we are accustomed to attach great value.

§95. It may be that these two extracts, those obtained by alcohol and sodic hydrate, respectively, do stand in some immediate relation to the respective values of the two hays, but some facts to be presented subsequently in connection with another fodder, while not showing that the above inference is wrong, will lead us to hesitate in drawing conclusions too freely.

§96. The substances removed by chlorination, including subsequent treatment with sodic hydrate and sulfurous acid, was 16 grams in the case of the native hay, 274 grams in that of the alfalfa, the former having a coefficient of 3.28 per cent., and the latter 25.39 per cent., both very low. The residue, which I have designated as cellulose though I know it is not pure, amounts to 1,502 grams in the native hay and 1,442 grams in the alfalfa, much more nearly equal than one would expect. The same, too, being true of the coefficients of digestion, as we find 50.57 for the cellulose from the native hay and 52.67 for that from the alfalfa.

§97. If we study the distribution of the nitrogen in the various extracts and the coefficients of digeston obtained, we find even greater differences, because we deal with smaller numbers and there is, too, a marked difference in the quantity of this element in the two fodders, the alfalfa being much the richer, containing almost 24 times as much nitrogen.

TABLE XLII.

The following figures represent grams of proteids (N. x 6.25).

DIGESTIBILITY OF THE PROTEIDS IN THE RESPECTIVE EXTRACTS.

	Native Hay		Alfalfa Hay	
	Grams	Coefficients	Grams	Coefficients
Alcohol, 80%	115.0	62.98	486.0	81.77
Cold water, hot water and malt	16.0	32.34	63.0	25.91
Hydric chlorid, 1%	57.0	67.34	132.0	72.38
Sodic hydrate, 1%	184.0	58.63	649.0	80.89
Chlorin, etc.	———	———	12.0	30.19
Cellulose	———	———	3.0	16.48

§98. We have not only a very much larger amount of proteids in the alfalfa, but also very much higher coefficients of digestion. Both hays show that sodic hydrate and alcohol are the two solvents removing the nitrogen. The hydric chlorid standing third in the list, removing one-half as much from the native hay and almost one-third as much from the alfalfa as the alcohol.

§99. In this connection the amid nitrogen should probably be considered; at least, the relative amounts in the hays should be given. The alfalfa consumed contained amid nitrogen corresponding to 337.45 grams proteids, with a coefficient of digestion of 81.55. The native hay contained an amount corresponding to 54.29 grams, the whole of which was digested, as no amid nitrogen was found in the feces.

§100. If we next compare the sugars contained in these two hays, we will find still other differences.

TABLE XLIII.

DIGESTIBILITY OF THE CARBOHYDRATES, MEASURED BY THE REDUCING POWER OF THE INVERTED EXTRACTS.

	Native Hay		Alfalfa Hay	
	Grams	Coefficients	Grams	Coefficients
Alcoholic extract, Sucrose	142.0	100.00	159.0	100.00
Alcoholic extract, Glucose	336.0	100.00	110.0	100.00
Cold water, gums, etc	256.0	100.00	83.0	81.09
Hot water and malt, starch	117.0	100.00	145.0	93.73
Hydric chlorid, 1% invert. sugar	830.0	62.58	286.0	83.96
Sodic hydrate, 1% invert. sugar, very minute quantity.				

§101. Except in the case of sucrose and starch, we find that the native hay contains more of these substances, or complexes yielding them, than the alfalfa. The most marked instance is the reducing power yielded by the hay on being treated with the one per cent. hydric chlorid, whereby hydrolysis effected the production of sugar equal to 1,326 grams of xylan, of which 830 grams were digested, whereas, in the alfalfa, the same treatment produced 340

grams galactan, of which 286 grams or 83.96 per cent. were digested. The differences here are quite marked and, so far as the quantity digested is concerned, apparently in favor of the native hay.

§102. If we, in like manner, compare the results obtained by determining the furfurol, we will observe that other differences are strongly indicated.

TABLE XLIV.

FURFUROL DIGESTED.

	Native Hay		Alfalfa Hay	
	Grams digested	Coefficients	Grams digested	Coefficients
Alcoholic extract	35.0	61.99	133.0	96.51
Cold water	3.0	6.79	78.0	100.00
Hot water and malt			67.0	67.44
Hydric chlorid, 1%	268.0	44.04	189.0	100.00
Sodic hydrate, 1%	130.0	42.16	55.0	27.81
Chlorin, sodic hydrate, etc.	....	.....	....	.....
Cellulose	164.0	74.94	171.0	72.62

§103. We observe that the furfurol yielding substances in these two fodders must be very different. Those removed by alcohol, water and hydric chlorid from the alfalfa hay having a much higher coefficient of digestion than those dissolved out of the native hay, while the furfurol yielding bodies removed by the one per cent. sodic hydrate from the alfalfa show a low coefficient of digestion, much lower even than the corresponding substances in the native hay. When we come to the portion that I have designated cellulose, we find the amount of furfurol digested in the two cases and also the coefficients of digestion very close together, so that this factor would apparently fall out of our consideration. The same is indicated by the amount of cellulose digested in these two cases, the three sheep having digested 1,441 grams cellulose fed as alfalfa and 1,502 grams fed as native hay. As pure cellulose yields from 2 to 2.5 per cent. of furfurol, and we obtained for the alfalfa cellulose 1.919 and for that from the native hay, 2.041 per cent. furfurol. the two products are probably almost pure cellulose, and the above results in regard to the cellulose are such as we should expect.

§104. In the case of the native hay, we find that the coefficients of digestion for the furfurol are low, except in the case of that yielded by the cellulose. The most marked features are the deportment of those compounds yielding furfurol, but which are soluble in one per cent. solutions of hydric chlorid or sodic hydrate. Such substances removed from alfalfa by one per cent. hydric chlorid seem to be wholly digestible, while those removed by the sodic hydrate are only slightly digestible. The alfalfa consumed contained substances soluble in the one per cent. hydric chlorid, which

yielded 180 grams furfurol, while those soluble in one per cent. sodic hydrate yielded 202 grams of furfurol. Those substances present in the native hay soluble in one per cent hydric chlorid yielded a total of 609 grams of furfurol, of which 44.04 per cent. was digestible; those soluble in one per cent. sodic hydrate yielded 308 grams of furfurol, of which 42.16 per cent. was digestible. Another very marked difference between these fodders is the solubility of the substances yielding furfurol in the different media, the furfurol yielded by the cellulose not being considered in the following statements. Hydric chlorid removes from the native hay almost exactly one-half of the furfurol—coefficient 44.04—while it removes about one-quarter of it from the alfalfa, coefficient 100. Sodic hydrate removes from the native hay one-quarter of the furfurol, coefficient 42.16; from the alfalfa one-quarter, with a coefficient of digestibility of 27.81.

§105. The one per cent. sodic hydrate solution seems to remove very considerable amounts of material which is capable of yielding furfurol from both of these fodders, but we were unable to obtain more than minute quantities of reducing sugars in the inverted extracts, which is contrary to what we would expect if this furfurol is derived from pentosans.

§106. The heat values of these two hays, alfalfa and native hay, show more directly, probably, than any other factors their relative values. We find that the animals appropriated 39,510,751 calories when fed on alfalfa, and 22,255,418 calories when fed on the native hay. The same sheep were used in these two experiments, both made under favorable conditions, so that the questions of individualty, etc., are removed as far as far as possible. The net result was a gain of 9 pounds in the one case, alfalfa, and three and one-half pounds in the other, native hay.

§107. Other sheep were used in the experiment with timothy hay, but the conditions were as favorable as we could make them. The energy consumed was 17,406,363 calories, and the result was a net loss of one pound.

CORN FODDER.

§108. The fodder used was in good condition. The stalks were rather heavy for sheep feeding and the amount refused by them was, on this account, rather large. The corn was a variety of dent and had been grown in drills in which the seed had been thinly sown. The fodder was cut in lengths not exceeding one-half inch before feeding. The sheep ate it readily, but refused the heavier stocks, nor could we induce them to eat this portion by grinding it. Each of the three sheep used in this experiment gained weight while being fed on it. No other food was fed in connection with it. The

coefficients of digestion for this fodder were found to be quite good, excepting that that for the proteids was much below the average, as we found 36.04 as the coefficient of digestibility for these substances, whereas the average found by other experimentors is 56.1. The total proteids in this fodder is slightly above the average. I know of no reason for the low coefficient, but I have elsewhere observed that the coefficients obtained by us are apt to be below those found by others, due, probably, to the conditions under which our fodders are preserved.

TABLE XLV.

ANALYTICAL DATA FOR CORN FODDER.

FODDER ANALYSIS.

CORN FODDER.		CORRESPONDING FECES. Sheep No. 1.	
Moisture	8.21	Moisture	6.73
Ash	9.53	Ash	12.63
Ether extract	1.55	Ether extract	1.12
Proteids	4.62	Proteids	7.16
Crude fibre	29.85	Crude fibre	30.16
Nitrogen-free extract	46.24	Nitrogen-free extract	42.20
	100.00		100.00

TABLE XLVI.

ANALYSIS OF THE ASH.

CORN FODDER.		CORRESPONDING FECES.	
Sand	13.048	Sand	23.796
Silicic acid	19.812	Silicic acid	38.867
Sulfuric acid	1.313	Sulfuric acid	1.063
Phosphoric acid	5.199	Phosphoric acid	5.158
Carbonic acid	10.319	Carbonic acid	0.060
Chlorin	3.495	Chlorin	0.571
Potassic oxid	28.366	Potassic oxid	3.626
Sodic oxid	2.603	Sodic oxid	0.759
Calcic oxid	6.090	Calcic oxid	10.625
Magnesic oxid	4.501	Magnesic oxid	6.500
Ferric oxid	1.530	Ferric oxid	1.909
Aluminic oxid	0.851	Aluminic oxid	1.343
Manganic oxid	0.260	Manganic oxid	0.170
Ignition	(3.401)	Ignition	5.685
	100.788		100.132
Oxygen equivalent to Cl	0.788	Oxygen equivalent to Cl	0.103
	100.000		100.029

TABLE XLVII.

ULTIMATE ANALYSIS.

CORN FODDER.		CORRESPONDING FECES.	
Carbon	42.661	Carbon	42.754
Hydrogen	5.892	Hydrogen	5.494
Nitrogen	0.739	Nitrogen	1.145
Sulfur	0.099	Sulfur	0.133
Chlorin	0.342	Chlorin	0.152
Ash	9.530	Ash	12.630
Oxygen (approx.)	40.737	Oxygen (approx.)	37.692
	100.000		100.000

§109. The chlorin and sulfur determinations were made on the fodder and not calculated from the ash. The oxygen percentage is only approximate, as the ash contains most of the sulfur and chlorin and probably oxygen taken up during the burning, and these elements enter the analysis in part, at least twice.

§110. The ratio of the air-dried feces to the weight of air-dried fodder consumed is 1:2.33; in the case of alfalfa it is 1:2.7. The portion of the corn fodder left by the sheep amounted to 24 per cent. of the fodder, while the portion of alfalfa left amounted to 7.38 per cent. This difference is considerable when considered in pounds only, but when the character of the two fodders is taken into consideration, the proportion of the corn fodder consumed seems quite favorable. The ratio of the leaves in this fodder to the stems was 2:1, which is not very different from the ratio of leaves to stems in the alfalfa plant, but the corn stalk is very different from the alfalfa stem. Sheep will not eat the alfalfa stems when they are coarse; this is probably due to the hardness of the stems, but, in the case of the corn stalks, they will not eat them even when they have been ground. The results show that only about 10 per cent. or even less of the corn stalks was eaten when cut in lengths of from ¼ to ½ inch. The fodder had been cut close to the ground, so that the whole of the plant was represented in the fodder.

§111. It was hoped that the elementary analyses of the fodders might show some differences suggestive of the wide differences in their actual feeding values, but the range in the ultimate composition of both the fodders and the feces shows that they are of but little value for the purposes of this study, as they show nothing more, that we can interpret, than the fodder analysis.

TABLE XLVIII.

CORN FODDER.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	29.243	29.985	29.614
Cold water, 24 hours, extracted.....	4.350	4.827	4.589
Hot water and malt extracted.....	3.881	2.603	3.241
Hydric chlorid, 1% sol. extracted....	19.550	20.244	19.897
Sodic Hydrate, 1% sol. extracted.....	13.891	13.692	13.792
Chlorin, etc., extracted	3.075	4.020	3.547
Cellulose	26.010	24.630	25.320
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	5.24	5.29	5.26
Sucrose in alcoholic extract.....	4.44	4.09	4.27
Gums in cold water extract.....	0.58	0.45	0.52
Starch in hot water extract.....	None	None	None
Xylan* in hydric chlorid extract.....	12.07	10.88**	12.07
Xylan in sodic hydrate extract.....	0.72	0.63	0.63

TABLE XLIX.

CORN FODDER ORTS.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol.....	28.429	27.978	28.20
Cold water, 24 hours.....	2.538	3.379	2.96
Hot water	2.657	1.985	2.32
Hydric chlorid 1% sol.	20.149	20.584	20.37
Sodic hydrate, 1% sol.	14.590	15.443	15.02
Chlorin, etc.	3.626	3.684	3.66
Cellulose	28.011	26.947	27.48
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	8.48	8.79	8.64
Sucrose in alcoholic extract.....	2.35	2.49	2.42
Gums in cold water extract.....	0.47	0.47	0.47
Starch in hot water extract.....	None	None	None
Xylan in hydric chlorid extract†.....	16.32	17.02	16.67
Xylan in sodic hydrate extract.....	0.86	0.73	0.80

*There is some galactan present, in two trials we obtained 0.680 and 0.706%. Other trials did not agree in quantity but all showed presence of galactan. Galactan is easily hydrolyzed. This extract is not. The feces also gave a slight precipitate for mucic acid.

**Rejected, inversion incomplete.

†According to the mucic acid determination, there is a small amount of galactan present, but the 16.32% of sugar present is so large that I have calculated it all as Xylan.

TABLE L.

CORN FODDER FECES.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	16.71	16.27	16.50
Cold water, 24 hours, extracted.....	4.38	4.66	4.53
Hot water and malt extracted.....	3.70	3.31	3.51
Hydric chlorid, 1% sol. extracted....	13.49	14.99	14.24
Sodic Hydrate, 1% sol. extracted.....	23.55	Lost	23.55
Chlorin, etc., extracted	11.12		11.12
Cellulose	26.55		26.55
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	None	None	None
Sucrose in alcoholic extract.....	None	None	None
Gums in cold water extract.....	0.36	0.36	0.36
Starch in hot water extract.....	None	None	None
Xylan in hydric chlorid extract.....	2.23	3.23	2.73
Xylan in sodic hydrate extract.....	2.44	Lost	2.44

TABLE LI.

CORN FODDER—COEFFICIENTS OF DIGESTION OF THE VARIOUS EXTRACTS.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Alcoholic extract 3461.4		737.2	2424.2	635.4	1738.8	73.79
Cold water extract..... 536.4		77.4	459.0	174.4	284.6	54.16
Hot water and malt ext... 378.8		60.6	318.2	135.2	183.0	54.37
Hydric chlorid, 1% extract. 2325.7		532.5	1793.2	548.4	1244.8	69.42
Sodic hydrate, 1% extract. 1612.1		392.7	1219.4	877.1	342.3	36.27
Chlorin, etc. 414.1		95.8	318.3	431.7	(—113.4)	
Cellulose 2959.5		718.4	2241.1	1030.9	1210.2	54.00
			8773.41	3833.1	4940.3	56.31

The general coefficient of digestion for the dry matter in corn fodder was found to be 56.66 per cent.

TABLE LII.

CARBOHYDRATES IN CORN FODDER AND THEIR COEFFICIENTS OF DIGESTIBILITY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose	656.9	225.9	431.0	0.0	431.0	100.00
Sucrose	499.1	58.6	440.5	0.0	440.5	100.00
Gums, etc.	60.8	12.3	48.5	13.8	34.7	71.56
Starch	0.0	0.0	0.0	0.0	0.0	——
Xylan, 1% hydric chlorid..	1410.8	435.8	975.0	105.1	869.9	89.22
Xylan(?) 1% sodic hydrate	73.6	20.9	52.7	94.0	(-41.3)	——
Cellulose 2959.5		718.4	2241.1	1030.9	1210.9	54.00

TABLE LIII.

FURFUROL FOUND IN CORN FODDER AND IN THE CORRESPONDING ORTS AND FECES.

	Cornfodder Per cent.	Orts Per cent.	Feces Per cent.
Original	11.476	10.625	10.997
Residue after treatment with 80% alcohol	10.792	10.530	10.894
Residue after treatment with cold water	10.768	same	same
Residue after treatment with hot water and malt	10.394	same	same
Residue after treatment with 1% hydric chlorid	5.342	5.841	7.536
Residue after treatment with 1% sodic hydrate	2.636	2.655	3.350
Residue after treatment with chlorin, etc., Cellulose	1.799	1.649	Not det.

TABLE LIV.

COEFFICIENT OF DIGESTION OF FURFUROL IN CORN AND THE PORTION DISSOLVED OUT BY THE VARIOUS SOLVENTS USED.

	Fed.	Orts.*	Consumed.	Voided.	Digested.	Coef.
Corn fodder	1341.4	277.8	1063.6	423.5	640.1	60.20
Soluble in 80% alcohol	80.0	2.5	77.5	4.0	73.5	94.80
Soluble in cold water	2.8**	———	2.8	0.0	2.8	100.00
Soluble in hot water and malt	43.7	———	43.7	0.0	43.7	100.00
Soluble in 1% hydric chlorid	590.3	122.6	467.7	125.5	342.2	73.17
Soluble in 1% sodic hydrate	316.3	80.3	236.0	160.9	75.1	31.82
Soluble in chlorin, etc.	97.8	26.3	71.5	129.0	62.3	32.57
Remaining in the cellulose	162.9	43.1	119.8			
			1019.2		479.8	47.07

METHOXYL GROUP IN CORN FODDER.

§112. The average percentage of this group found in the fodder was 1.445, and in the feces 2.033. In discussing this group under the subject of alfalfa, I stated that the results were probably rather low, basing this judgment on the check results obtained on a commercial sample of quinine. This observation applies to all of the samples and particularly, perhaps, to this case, as the amount found in the feces is the lowest in the series.

§113. The assumption that the orts and fodder were so nearly alike that no material error is made by taking them as the same is probably wrong in this case, for the orts were nothing other than corn stalks, which were so hard that the sheep did not eat them. They consisted essentially of the hard parts of the stalk and pith.

*These orts consisted wholly of pieces of stalks too hard for the sheep to eat.

**This figure has, as will readily be understood, no value, but it is the result that we obtained.

§114. The amount of this group, methoxyl, consumed was 129.67 grams, that voided was 78.27 grams, digested 51.40 grams, percentage digested 39.64.

AMID NITROGEN IN CORN FODDER.

§115. The total amid nitrogen found was very small, that found in the fodder was 0.077 per cent., equal to 0.481 per cent. of proteids; that found in the orts was 0.045 per cent., equal to 0.281 per cent. of proteids. We found none in the feces. The total is very small, but it is evident that we have to attribute to it a coefficient of digestion of 100.00.

TABLE LV.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS IN THE VARIOUS EXTRACTS OF CORN FODDER.

Solvent.	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Boiling 80% alcohol	248.96	33.20	215.76	74.46	141.30	65.49
Cold water	32.73	1.83	30.90	25.85	5.05	16.30
Hot water and malt....	26.89	3.49	23.49	21.22	2.27	9.66
1% hydric chlorid	79.48	9.41	70.07	42.44	27.63	39.43
1% sodic hydrate	115.71	16.73	98.98	110.72	(—11.74)	———
Chlorin, sodic hydrate and sulfurous acid ..	30.39	1.57	28.82	15.43	13.39	46.46
Remaining in cellulose..	5.85	1.05	4.80	4.24	0.56	11.67
	540.01	67.19	472.82	294.36	178.46	37.74

§116. The coefficients found for the three sheep were 37.18, 37.49, 33.45; average 36.04 per cent.

THE CALORIFIC VALUE OF CORN FODDER AND ITS VARIOUS EXTRACTS.

§117 The calorific value of the dry corn fodder was found to be 4,244 calories, and the total heat units fed amounted to 45,533,876; the total value of the feces was 15,258,816 calories; the total heat value of the orts was 10,850,880 calories; the sheep therefore appropriated 19,424,180 calories, or 56 per cent. of that consumed.

§118. The sheep gained weight, 3½ pounds, during the five days that the test lasted. The gain was for the different sheep 2, 1 and ½ pounds, respectively. The number of heat units appropriated by the sheep is less than in the case of the native hay, 22,255,418 calories, while the gain in weight is the same; the coefficient of digestion, however, is higher, it being in the case of the native hay 48.34 per cent., and in the corn fodder 56 per cent. In timothy hay it was 47.83 per cent., and the heat units appropriated by the sheep were 17,406,363. One of the sheep gained and two lost, resulting in a net loss of one pound for the three sheep:

Timothy hay, heat units appropriated, 17,406,363, loss 1.0 pounds.
Corn fodder, heat units appropriated, 19,424,180, gain 3½ pounds.
Native hay, heat units appropriated, 22,255,418, gain 3½ pounds.
The percentages of the heat units thus used by the sheep are 47.83, 56.00 and 48.34.

TABLE LVI.

The dry corn fodder gave the following extracts and residue:

	Per cent.
Soluble in 80% alcohol	23.32
Soluble in cold water	5.00
Soluble in hot water and malt	3.54
Soluble in 1% hydric chlorid	21.63
Soluble in 1% sodic hydrate	15.03
Soluble in Chlorin, etc.	2.86
Residue, Cellulose	27.57
	100.00

§119. The distribution of the ash in these extracts was not determined and, consequently, no correction has been made on account of it.

TABLE LVII.

The calorific values of the dry fodder and the respective residues were as follows:

	Calories.
The dry fodder	4244
Residue after extraction with 80% alcohol	4250
Residue after extraction with cold water	4405
Residue after extraction with hot water and malt	
Residue after extraction with 1% hydric chlorid	4459
Residue after extraction with 1% sodic hydrate	4201
Residue after extraction with chlorin, etc.	4134

TABLE LVIII.

CALORIES REMOVED BY THE SUCCESSIVE TREATMENTS.

One gram of corn fodder yields to 80% alcohol	985 calories
One gram of corn fodder yields to cold water	257 calories
One gram of corn fodder yields to hot water and malt	
One gram of corn fodder yields to 1% hydric chlorid	930 calories
One gram of corn fodder yields to 1% sodic hydrate	752 calories
One gram of corn fodder yields to chlorin, etc.	180 calories

TABLE LIX.

CALORIFIC VALUES OF THE EXTRACTS OF CORN FODDER.

One gram of alcoholic extract equals	4224 calories
One gram of cold water extract equals	3009 calories
One gram of hot water and malt extract equals	
One gram of 1% hydric chlorid extract equals	4290 calories
One gram of 1% sodic hydrate extract equals	5003 calories
One gram of chlorin, etc., extract equals	4665 calories
One gram of residue, cellulose, equals	4134 calories

TABLE LX.

The dry feces gave the following extracts and residue:

APPROXIMATE ANALYSIS OF THE DRY FECES.

	Per cent.
Soluble in 80% alcohol	10.48
Soluble in cold water	4.86
Soluble in hot water and malt	3.76
Soluble in 1% hydric chlorid	15.27
Soluble in 1% sodic hydrate	25.25
Soluble in chlorin, etc.	11.92
Residue, cellulose	28.46
	100.00

TABLE LXI.

The distribution of the ash was not determined.

THE CALORIFIC VALUES OF THE DRY FECES AND THE RESPECTIVE RESIDUES.

The calorific value of the dry feces equaled	4248 calories
Residue after extraction with 80% alcohol	4153 calories
Residue after extraction with cold water Residue after extraction with hot water and malt	4252 calories
Residue after extraction with 1% hydric chlorid	4126 calories
Residue after extraction with 1% sodic hydrate	*3889 calories
Residue after extraction with chlorin, etc.	3714 calories

TABLE LXII.

CALORIES REMOVED FROM THE FECES (CORN FODDER) BY THE SUCCESSIVE TREATMENTS.

One gram of feces yields to hot 80% alcohol	530 calories
One gram of feces yields to cold and hot water and malt	236 calories
One gram of feces yields to 1% hydric chlorid	774 calories
One gram of feces yields to 1% sodic hydrate	1138 calories
One gram of feces yields to chlorin, etc.,	513 calories
One gram of feces yields a residue, cellulose	1057 calories
	4248 calories

TABLE LXIII.

CALORIFIC VALUES OF THE RESPECTIVE EXTRACTS OF THE FECES (CORN FODDER.)

One gram of the alcoholic extract equals	5057 calories
One gram of cold and hot water with malt equals	2738 calories
One gram of the 1% hydric chlorid extract equals	5069 calories
One gram of the 1% sodic hydrate extract equals	4507 calories
One gram of the chlorin, etc., extract equals	4304 calories
One gram of the residue, cellulose, equals	3714 calories

*We at first doubted this result, so another sample was started de novo and the determination repeated with the result that we obtained 3891 calories as the value of this residue.

TABLE LXIV.

COEFFICIENTS OF DIGESTION FOR THE FUEL VALUES OF THE VARIOUS EXTRACTS OF CORN FODDER.

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Alcoholic extract	10,238,976	3,211,195	7,027,781	71.10
Aqueous extracts	2,337,996	848,780	1,489,213	63.69
One per cent. hydric chlorid ext.	7,691,970	2,774,812	4,914,158	63.88
One per cent. sodic hydrate ext.	6,098,657	3,952,639	2,146,018	35.17
Chlorin, etc., extract	1,482,734	1,859,328	(-376,594)	....
Residue or cellulose	9,264.294	3,829,138	5,435,160	58.67

ALFALFA AND CORN FODDER COMPARED FROM THE STANDPOINT OF THEIR CALORIMETRIC RELATIONS.

§120. The two fodders first chosen for a complete study were alfalfa and corn fodder. In making this choice, I considered the fact that alfalfa is, beyond all question, our best fodder and, after it, for general all round purposes, corn fodder, probably stands next. Timothy is grown in considerable quantities in some sections of the state, but it is too limited in supply, and too high in price to be thought of as a general fodder, either by itself or for the purpose of balancing an alfalfa ration, unless it be for horses. Timothy has further been studied, and from this standpoint would have been, in part at least, a repetition of other work. Our native hay is a very much better fodder than timothy hay, but the supply of it is limited, the price is high, and its composition is variable, *i. e.*, the grasses, rushes and sedges forming it vary with localities and seasons. I chose corn fodder because it can be produced cheaply in large quantities over a large territory and because the results of feeding indicate that it is as good a fodder as the native hay and a very much better one than timothy hay. I was, in short, guided by the consideration of the utility of the respective fodders. It would have been a mistake to do so to the exclusion of other fodders, as my object has really not been to study good, acceptable fodders, but to discover, if possible, the reasons why one fodder is better than another, why one is good and another poor. While the difference between the values of corn fodder and alfalfa is considerable, it is not wide enough to give the best opportunity for presenting such a study with thoroughly satisfactory results. We will find larger differences when we come to the study of the saltbush, *Atriplex argentea*, which is an exceedingly poor fodder.

§121. There are very salient and interesting contrasts between these two fodders, alfalfa and the saltbush, *Atriplex argentea*, which I may digress to state briefly. The sheep fed on alfalfa gained nine pounds; those fed on saltbush lost eight and one-half pounds in five days. It is true that the sheep to which alfalfa was

fed digested a larger amount of dry matter than those receiving saltbush, but not so much more as the difference of 17½ pounds of flesh would apparently indicate. The sheep receiving alfalfa digested 7,246 grams of dry matter, containing 1,315 grams of proteids, 3,274 grams of nitrogen-free extract and 1,875 grams of crude fibre; those receiving saltbush digested 7,051 grams of dry matter, containing 1,116 grams of proteids; 3,011 grams of nitrogen-free extract and 342 grams of crude fibre. The mineral matter contained in the saltbush and digested was very large, 2,315 grams against 779 grams digested with the alfalfa. These are the differences, total dry matter, 195 grams; crude proteids, 199 grams; nitrogen-free extract, 263 grams; crude fibre, 1,533 grams—all the differences so far being in favor of the alfalfa. In the case of the mineral matter, the sheep fed on the saltbush digested 1,536 grams more than those receiving alfalfa. The daily differences in the amounts digested per sheep for the various fodder constituents were as follows: Crude proteids 12.66 grams, nitrogen-free extract 17.5 grams, both in favor of the alfalfa-fed sheep, which were gaining six-tenths of a pound daily, while the saltbush-fed sheep were losing almost exactly the same amount. The only food element digested in considerable excess by the alfalfa-fed sheep, 102 grams daily per sheep, was the crude fibre. This may be the cause of the great difference in the results.

§122. It is not evident what part the mineral matter may have played, though the amount actually absorbed by the sheep was large, 2,315 grams for the three sheep in five days, it produced no looseness of the bowels or other inconveniences that we could observe. This fodder did provoke a marked thirst, but the sheep did not suffer on this account. It does not seem probable that the loss of flesh was due to the mineral constituents contained in the plant. If we may reason from analogy in this case, we would be justified in comparing its results with those produced by sugar beet tops, which contain from 22 to 30 per cent. of ash when dried. The compounds absorbed in the case of the saltbush appear to be the sulfuric acid, chlorin and the alkalies. In eating a like amount of dried sugar beet tops the animals would consume larger amounts of these compounds than in the case of the saltbush, but it is a matter of common experience and knowledge that sheep thrive on the beet tops. If analogy holds in the case, we are justified in adopting the proposition that the loss is probably not due to the inorganic matter digested.

§123. Returning to our comparison of the energy relations of the alfalfa and the corn fodder, it is to be remembered that both fodders proved to be good ones. The alfalfa, however, producing a much greater gain in live weight than the corn fodder did under

the conditions of the experiment. The corn fodder, however, considering the coarseness of a large portion of it, one-third of it being stalks which the sheep ate very reluctantly, produced excellent results. I endeavored to induce the sheep to eat as much of the corn fodder as possible, so their ration was not made large enough to encourage them in selecting the most acceptable portions of the fodder. I do not know how much virtue there may be in the corn stalks, but they are certainly in no manner comparable to the stems of alfalfa, whose composition indicates that, without any leaves, they constitute a better fodder than some hays which are held in fair esteem, but sheep will not eat even these when coarse and hard.

§124. The amount of energy appropriated by the animal and the effect produced per unit of heat are the important points, especially from the standpoint of the feeder. Each gram of water free alfalfa is equivalent to 4,363 calories, 62.43 per cent. of which is available, and each gram of corn fodder is equivalent to 4,244 calories, 56 per cent. of which is available, *i. e.*, is taken up by the animal. The sheep receiving alfalfa appropriated 30,955,663 calories and those receiving corn fodder appropriated 19,424,180 calories, a difference of 11,531,483 calories. The former gained nine pounds in weight, the latter three and a half pounds, a difference of five and one-half pounds, which would indicate the consumption of 2,096,634 calories in the form of alfalfa for the production of one pound of gain in the live weight, which corresponds to very nearly two pounds of alfalfa, taking 453 grams as a pound and 62 as the percentage of heat appropriated by the sheep. The energy actually necessary to maintain the animals is considered to be the same in both cases; this is an assumption which is probably not wholly justified, neither is it shown that like amounts of energy in the corn fodder and alfalfa will produce the same results in pounds of mutton as is here tacitly assumed. The calorific value of the urine was not determined in either case, neither was the nitrogen in it determined.

§125. As already stated, the total dry matter consumed by the alfalfa fed sheep was 11,365 grams, while those receiving corn fodder consumed but 8,289. The dry matter digested was 7,046 and 4,642 grams, respectively. The coefficients of digestion found for this dry matter were 62.08 and 56.66, respectively. The percentages of the heat appropriated were very nearly the same as these coefficients, viz: 62.43 and 56.00 per cent. One would scarcely anticipate so close an agreement.

§126. The distribution of the heat values in the different extracts and the coefficients of these extracts, together with their respective amounts, show great differences between the fodders.

TABLE LXV.

	Alfalfa Extract Per cent.	Coefficient	Cornfodder Extract Per cent.	Coefficient
80% alcohol	27.50	73.88	29.61	73.79
Cold water	8.66	78.89	4.59	54.16
Hot water and malt	4.37	70.24	3.24	54.37
1% hydric chlorid	12.23	60.20	19.90	69.42
1% sodic hydrate	16.19	67.72	13.79	36.27
Chlorin	8.76	25.39	3.55	———
Residue	22.29	52.67	25.32	54.00

§127. The most patent difference here is in the case of the sodic hydrate, both in the quantity that is soluble and in the coefficient of digestion. The difference of about 2 per cent. in favor of the portion dissolved out of the alfalfa by the caustic soda is much less than the relative amounts of proteids present in the fodders; while the difference in the amount soluble is only 2 per cent., the coefficient of digestibility is more than double that of the portion dissolved out of the corn fodder.

TABLE LXVI.

THE CALORIFIC VALUE OF THE FODDERS AND THEIR RESPECTIVE EXTRACTS.

	Alfalfa	Corn Fodder
Original fodder	4363	4244
Extracts:		
Alcoholic (hot 80% alcohol)	4706	4224
Cold and hot water	3140	3009
One per cent. hydric chlorid	3596	4290
One per cent. sodic hydrate	5063	5003
Chlorin, etc.	5598	4663
Residue, cellulose	4210	4134

TABLE LXVII.

CALORIFIC VALUES OF THE FECES AND THEIR EXTRACTS.

	Alfalfa	Corn Fodder
Original	4525	4248
Extracts:		
Alcohol (hot 80% alcohol)	5739	5057
Cold and hot water	4123	2738
One per cent. hydric chlorid	4061	5069
One per cent. sodic hydrate	2997	4507
Chlorin	5842	4304
Residue, cellulose	4294	3714

TABLE LXVIII.

THE COEFFICIENTS OF DIGESTION FOR THE HEAT VALUES OF THE VARIOUS EXTRACTS OF ALFALFA AND CORN FODDER.

ALFALFA.

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Alcoholic extract	15,852,166	5,113,449	10,738,717	67.75
Aqueous extracts*	5,074,240	1,599,724	3,474,516	68.51
1% hydric chlorid extract	5,447,940	2,448,783	2,999,157	54.75
1% sodic hydrate extract	10,156,378	1,938,059	8,218,319	80.92
Chlorin, etc., extract	6,045,840	4,708,652	1,337,188	24.03
Residue or cellulose	11,522,770	5,570,208	5,952,562	51.66

CORN FODDER

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Alcoholic extract	10,238,976	3,211,195	7,027,781	71.10
Aqueous extracts	2,337,996	848,780	1,489,213	63.69
1% hydric chlorid extract	7,691,970	2,774,812	4,914,158	63.88
1% sodic hydrate extract	6,098,657	3,952,639	2,146,018	35.17
Chlorin, etc., extract	1,482,734	1,859,328	(— 376,594)	———
Residue or cellulose	9,264,294	3,829,138	5,435,160	58.67

§128. Though the preceding table is based upon the calorific values of the extracts calculated from the values of the residues, the total differs, in the case of the alfalfa, from that obtained by using the values obtained for the hay and feces by about 5 per cent., which is a closer agreement than I had anticipated. In the case of the corn fodder, the agreement is not so good, but is, even in this case, only 9.3 per cent; the calculated values being the higher in both cases.

§129. These results show that the fodders agree in this, that the alcoholic extract and the cellulose furnish a large percentage of the total heat value appropriated by the sheep, 16,691,297 calories out of a total of 31,720,459 calories, or 51 per cent., approximately The heat yielded by the cellulose in the two fodders is nearly the same. The hydric chlorid and sodic hydrate extracts are reversed in the two fodders; that is, the sodic hydrate extract shows a very much higher value in the alfalfa and a very much lower one in the corn fodder than the hydric chlorid extract, yielding almost three times as much heat in the case of alfalfa and less than half as much in that of the corn fodder. The high proteid content of the alfalfa may correspond to the higher heat value of the sodic hydrate extract, but the distribution of the nitrogen among the extracts does not lend much probability to this idea, for the sodic hydrate solu-

*Aqueous extract includes all that was dissolved out by successive treatment with cold water, boiling with water for one hour and subsequent digestion with malt extract.

tion dissolves only about one-half of the nitrogen contained in the alfalfa, the other half being contained in the alcoholic extract (7-19) and in the hydric chlorid extract (1-10). The relative amounts of heat appropriated by the animals from these two extracts is remarkably different, 80.9 per cent. of that from the alfalfa being appropriated, while only 35.17 per cent. of that from the corn stalks. In the alfalfa the three portions, *i. e.*, extracts obtained by treatment with alcohol, and sodic hydrate and the residue, or that portion which we have called cellulose, yield five-sixths of the available heat; in the corn fodder it is the extracts removed by alcohol, hydric chlorid and the residue or cellulose that furnish almost six-sevenths of the total heat.

§130. These two fodders agree in showing that the alcoholic extract and the cellulose are two important factors in a fodder; they differ in regard to the third factor, one indicating that the portion soluble in sodic hydrate and the other that that soluble in hydric chlorid, is the third in importance. This is probably the big difference between the two, though both are capable of furnishing more energy than is necessary to simply maintain the animal and contain no constituent whose physiological action is detrimental.

§131. There are many hints that the results are modified to a considerable extent by the fecal matter proper, but it is not separable from the undigested residue of the fodder.

§132. The difference between the sodic hydrate extracts in these two cases is great, not only in the quantity of heat represented, but also in the availability of the heat value of the substances taken into solution. The sheep consumed, in round numbers, ten millions heat units with the alfalfa which had proven insoluble in the alcohol, water and hydric chlorid, of which 80.92 per cent. were available, while the others consumed but six millions from the corn fodder, of which only 35.17 per cent. were available, making an actual difference of over six millions of heat units obtained from this portion of these fodders. These quantities are those actually consumed and appropriated by the sheep and not comparisons based on like weights of the fodders. Such a comparison would result in a more favorable showing for the corn fodder.

§133. The distribution of the nitrogenous substances in the various extracts of alfalfa hay have been given in a previous table [illegible] nearly 50 [illegible] corn fodder. The big feature in the case of the [illegible]rances is insoluble in al[illegible]cohol water and hydric chlorid but soluble in sodic hydrate and, fu[illegible]ther, that 80.89 per cent. of the total, soluble in sodic hydrate, is d[illegible]gestible. This ratio holds, too, for native hay, but the coefficient of[illegible] digestion for the nitrogenous mat-

Chl[illegible]
Residue, [illegible]

ters soluble under these conditions is but 58.63 per cent. In the corn fodder we have an entirely different distribution of the proteids among the various extracts, over two thirds of the total digestible nitrogenous substances being soluble in boiling eighty per cent. alcohol and nearly one-half of the nitrogen consumed is soluble in the same menstruum. The large amount of nitrogen, calculated as proteids, in the feces, soluble in sodic hydrate, points clearly, as I interpret it, to the presence of nitrogenous fecal matter, even in excess of the total amount, soluble in this reagent, present in the fodder consumed. This is the most marked instance, so far met with, indicative of the disturbing influence of fecal matter upon the results of our work, but it is not the only one. It seems to be almost a rule that the nitrogen removable by treatment with chlorin, sodic hydrate and sulfurous acid is greater in the feces than in the fodder consumed, though in this particular case it is less. The amount of nitrogen involved in this portion, nitrogen removable by treatment with chlorin, etc., as well as that contained in the final residue, designated cellulose, and also in the portion removed by successive treatment with cold water, hot water and malt, is quite small and, for this reason, of little importance. Their frequent excess in the feces points to the influence of the presence of fecal matter, which differs in the case of different fodders.

§134. The results of the study of the distribution of the nitrogen in the respective extracts, as well as the distribution of the heat values of the extracts, indicate that the greatest differences between these two fodders is in the character of the two extracts obtained by hydric chlorid and sodic hydrate. In studying the results, it is to be borne in mind that there are actually a larger edible ration fed in the case of the alfalfa than in that of the corn fodder, because, as before stated, I tried to induce the sheep to consume the largest possible portion of the corn fodder fed. I am quite convinced that I would have obtained results more favorable to the corn fodder had I fed them from one-third to one-half more of it and thus made it possible for the sheep to select the portions which they liked to a greater extent than they did. There was eaten 11,365 grams of dry matter as alfalfa, and but 8,289 grams as corn fodder. In order to have induced the sheep to eat the same amount of corn fodder as they actually did eat of alfalfa, it would probably have been necessary to increase the ration by one-half. I have so far purposely avoided comparing these fodders weight for weight. It may be well to do so, but very briefly. The three sheep appropriated 19,424,180 calories from the 8,289 grams of corn fodder consumed, or 2,344 calories per gram, while a like number of sheep appropriated 30,955,663 calories from 11,365 grams of alfalfa, or 2,736 calories per

gram, which shows a difference in favor of the alfalfa of only 392 calories per gram of fodder eaten.

SORGHUM FODDER.

§135. This fodder was grown in the extreme eastern part of the State without irrigation. It was cut when a few canes were far enough advanced to mature the seed in shock. The fodder stood in shock till the latter part of the winter, but was not fed till the latter part of the spring. The variety was Minnesota Early Amber.

The following is the analytical data:

TABLE LXIX.

FODDER ANALYSIS.

SORGHUM FODDER.		CORRESPONDING FECES.	
		Sheep No. 1.	
Moisture	5.75	Moisture	6.80
Ash	8.17	Ash	11.46
Ether extract	1.55	Ether extract	1.28
Proteids	5.80	Proteids	8.48
Crude fibre	23.26	Crude fibre	28.16
Nitrogen-free extract	55.47	Nitrogen-free extract	43.82
	100.00		100.00

TABLE LXX.

ASH ANALYSIS.

SORGHUM.		CORRESPONDING FECES.	
Percentage of ash in fodder	8.77	Percentage of ash in feces	11.46
Carbon	0.000	Carbon	0.000
Sand	30.097	Sand	43.025
Silicic acid	7.220	Silicic acid	18.718
Sulfuric acid	1.893	Sulfuric acid	0.963
Phosphoric acid	2.838	Phosphoric acid	5.963
Carbonic acid	10.395	Carbonic acid	0.846
Chlorin	6.859	Chlorin	1.576
Potassic oxid	30.980	Potassic oxid	7.944
Sodic oxid	0.073	Sodic oxid	1.316
Calcic oxid	4.730	Calcic oxid	7.548
Magnesic oxid	3.588	Magnesic oxid	6.353
Ferric oxid	0.970	Ferric oxid	1.080
Aluminic oxid	0.443	Aluminic oxid	1.026
Manganic oxid	0.200	Manganic oxid	0.120
Ignition	(1.260)	Ignition	(3.877)
Sum	101.546	Sum	100.355
Oxygen-Chlorin	1.546	Oxygen-Chlorin	0.355
	100.000		100.000

TABLE LXXI.

ULTIMATE ANALYSIS.

SORGHUM.		CORRESPONDING FECES.	
Carbon	42.402	Carbon	43.926
Hydrogen	5.748	Hydrogen	5.825
Nitrogen	0.928	Nitrogen	1.362
Sulfur	0.085	Sulfur	0.115
Chlorin	0.553	Chlorin	0.305
Ash and oxygen	50.284	Ash and oxygen	48.466
	100.000		100.000

§136. The average coefficients of digestion found for this fodder were as follows: Dry matter, 58.46; ash, 44.61; fat, 64.87; proteids, 43.06; crude fibre, 49.23; nitrogen-free extract, 61.06. The three animals to which this fodder was fed lost eight and one-half pounds in five days and consumed 30 to 31 pounds of dry matter per thousand weight of animal. The fodder was evidently acceptable to the animals, but the results were unfavorable.

TABLE LXXII.

PROXIMATE ANALYSIS.

SORGHUM FODDER.	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted	35.492	35.727	35.60
Cold water, 24 hours, extracted	3.966	4.065	4.02
Hot water extracted	7.634	7.468	7.55
Hydric chlorid 1% sol. extracted	18.955	17.480	18.22
Sodic hydrate 1% sol. extracted	11.048	11.982	11.52
Chlorin, etc., extracted	4.327	4.579	4.45
Cellulose	18.578	18.699	18.64
SUGARS IN THE EXTRACTS.			
Glucose in alcoholic extract	9.31	9.46	9.39
Sucrose in alcoholic extract	6.80	7.22	7.01
Gums in cold water extract	0.36	0.32	0.34
Starch in hot water extract	2.45	2.52	2.49
Xylan in hydric chlorid extract	13.59	13.78	13.68
Xylan in sodic hydrate extract	0.66	0.68	0.67

TABLE LXXIII.

PROXIMATE ANALYSIS.

SORGHUM ORTS.	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted	41.809	42.624	42.21
Cold water in 24 hrs. extracted	2.960	3.040	3.00
Hot water extracted	2.581	2.400	2.49
Hydric chlorid 1% sol. extracted	17.499	17.412	17.46
Sodic hydrate 1% sol. extracted	12.474	12.727	12.60
Chlorin, etc., extracted	3.066	3.114	3.09
Cellulose	19.611	18.683	19.15

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	Lost	14.95	14.95
Sucrose in alcoholic extract.....	Lost	10.73	10.73
Gums in cold water extract.....	0.59	0.46	0.53
Starch in hot water extract.....	1.18	1.05	1.12
Xylan in hydric chlorid extract.....	14.94	15.51	15.23
Xylan in sodic hydrate extract.....	0.80	0.82	.81

TABLE LXXIV.

FECES OF SHEEP FED ON SORGHUM.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	15.180	14.986	15.08
Cold water in 24 hrs. extracted.....	3.728	3.669	3.70
Hot water extracted	4.190	5.005	4.60
Hydric chlorid 1% sol. extracted.....	22.481	22.205	22.34
Sodic hydrate 1% sol. extracted.....	20.461	20.270	20.37
Chlorin, etc., extracted	11.172	10.039	10.61
Cellulose	22.788	23.826	23.30
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	None	None	None
Sucrose in alcoholic extract.....	None	None	None
Gums in cold water extract.....	0.20	0.20	0.20
Starch in hot water extract.....	0.36	0.39	0.38
Xylan in hydric chlorid extract.....	13.45	13.14	13.30
Xylan in sodic hydrate extract.....	1.11	1.11	1.11

TABLE LXXV.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF SORGHUM FODDDER.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract..	4742.9	738.1	4004.8	731.3	3273.5	81.74
Total cold water extract.	535.6	52.5	483.1	179.4	303.7	62.86
Total hot water extract.	1005.9	43.6	962.3	223.1	739.2	76.82
Total hydric chlorid ext.	2427.5	305.3	2122.2	1083.3	1038.9	48.95
Total sodic hydrate ext..	1534.8	220.3	1314.5	987.8	326.7	24.85
Total chlorin, etc., ext...	592.9	54.0	538.9	514.5	24.4	4.53
Residue, cellulose	2483.4	334.9	2148.5	1129.9	1018.6	47.41
	13323.0	1748.7	11574.3	4849.3	6725.0	58.10

§137. The coefficients for the dry matter obtained with the three sheep were as follows: 57.53, 58.22 and 59.63; average 58.46 per cent.

TABLE LXXVI.

COEFFICIENTS OF DIGESTION FOR THE CARBOHYDRATES CONTAINED IN SORGHUM FODDDER.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose in alcoholic ext...	1251.0	261.4	989.6	0.0	989.6	100.00
Sucrose in alcohol extract.	934.0	187.6	746.4	0.0	746.4	100.00
Gums in cold water ext...	45.3	9.3	36.0	9.7	26.3	73.06
Starch in hot water ext...	331.7	19.6	312.1	18.4	293.7	94.11
Xylan in hydric chlorid ext	1822.6	266.3	1556.3	645.0	911.3	58.56
Xylan in sodic hydrate ext	89.3	14.2	75.1	53.8	21.3	28.26
	4473.9	758.4	3715.5	726.9	2988.6	80.43

TABLE LXXVII.

FURFUROL FOUND IN SORGHUM FODDER AND IN THE CORRESPONDING ORTS AND FECES.

	Sorghum Per cent.	Orts Per cent.	Feces Per cent.
Original	9.680	10.069	12.530
Residue after treatment with 80% alcohol...	9.410	9.856	12.016
Residue after treatment with cold water....	Same	Same	Same
Residue after treatment with hot water and malt	8.638	Same	11.628
Residue after treatment with hydric chlorid	3.322	4.626	4.662
Residue after treatment with sodic hydrate.	1.957	2.387	2.456
Residue after treatment with chlorin, etc....	1.746	1.641	Not det

TABLE LXXVIII.

COEFFICIENTS OF DIGESTION FOR FURFUROL IN SORGHUM AND IN THE PORTIONS DISSOLVED OUT BY THE VARIOUS SOLVENTS USED.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Sorghum	1290.5	176.1	1114.4	6076.	506.8	45.48
Soluble in 80% alcohol ...	36.0	3.7	32.3	24.9	7.4	22.91
Soluble in cold and hot water	10.3	5.4	4.9	18.8	(—13.9)	.....
Soluble in 1% hydric chlorid	708.3	86.0	622.3	337.8	284.5	45.72
Sol. in 1% sodic hydrate...	182.7	39.2	143.5	107.0	36.5	25.44
Soluble in chlorin, etc....	27.3	13.0	14.3	111.9	106.3	48.72
Remaining in the cellulose	232.6	28.7	203.9			
			1120.9	600.4	520.9	46.46

METHOXYL GROUP.

§138. The amount of this group found in the fodder was 1.027 per cent.; in the feces, 3.379 per cent. No determination of this group was made with the orts. The result shows an excess of 45 grams in the feces, which is due either to some mistake in the

determination or indicates the probable presence of this group in fecal matter. The results of our determinations, 14 in all, indicate a much higher percentage of this group in the feces than in the fodder consumed. The results in this case are very high for the feces, but it was done in triplicate and the three determinations agree very well.

AMID NITROGEN.

§139. The amount of amid nitrogen found in the sorghum was small, corresponding to only 0.884 per cent. calculated as proteids. We found none or only a trace in the orts and 1.168 per cent. in the feces. The coefficient of digestion found in this case was 51.91 per cent. This is somewhat higher than the coefficient found for the total nitrogen calculated as proteids, 8.95 per cent. higher.

HEAT APPROPRIATED BY THE ANIMALS.

§140. The air-dried fodder possessed a heat value of 3,890 calories per gram; the orts, 1,749 grams in weight, are supposed to have the same value; the feces, which weighed 4,849 grams, had a fuel value of 4,111 calories per gram. The sheep consumed 11,574 grams of air-dried fodder and appropriated 55.72 per cent. of its fuel value.

§141. We did not determine the distribution of the proteids in the various extracts of sorghum and their respective coefficients of digestion, neither did we make a detailed study of the fuel values of the respective extracts, etc.

§142. This fodder had already proved to be a disappointment, but not to as great an extent as the saltbush, so I scarcely hoped to gain anything by extending this work.

§143. The sheep fed on this fodder lost in the five days between the two weighings, 3, 2½ and 3 pounds, respectively, an aggregate loss of 8½ pounds. They appropriated in this period 25,088,621 calories, which was evidently not sufficient to maintain the animals in good condition. The coefficients of digestion for this fodder were quite as promising as those obtained for corn fodder, with the exception of that obtained for the crude fibre; the latter coefficient is nearly 8 per cent lower in the sorghum than in the cornfodder. The dry matter consumed by the sheep when fed corn fodder was 8,289 and 10,934 when fed sorghum; the same sheep were used in these two experiments and the conditions were equally favorable in both series. The sheep all gained on the corn fodder and lost while being fed the sorghum fodder. The sheep appropriated 19,424,180 calories while feeding on corn fodder, as against 25,088,621 while feeding on sorghum. The urine was unfortunately not collected

and analyzed. The water drank while feeding on corn fodder weighed 27½ pounds, and as the weather was cold, the water was warmed to about 22° C. before it was offered to the sheep. The weight of water consumed while feeding on sorghum was 60½ pounds and was not warmed, as the temperature of the water was at this time about 15° C. The daily consumption of water was a trifle over twice as much per sheep while feeding or sorghum as while feeding on corn fodder. In the former case, it was four pounds, and in the latter nearly two pounds per sheep. This amount of water, 4 pounds, is probably not excessive, as the sheep fed on alfalfa drank almost 4¾ pounds daily and made a gain of about three pounds each in the five days, but they did appropriate nearly 6,000,000 more calories than the sheep feeding on sorghum. The three sheep used in the experiment with the alfalfa were not the same three used in the sorghum experiment, but each of the sheep used in the alfalfa experiment gained about three pounds in five days, and each of those used in the sorghum lost about three pounds in five days.

§144. It is evident from the context that the gain and loss is in terms of live weight, this being the only kind of gain or loss considered in this bulletin.

SALTBUSH, *Atriplex argentea.*

§145. This plant is used to some extent in the eastern part of this state in making a hay to feed during heavy storms when the stock cannot otherwise obtain forage enough to sustain themselves. I undertook the study of this plant in the hope that it might prove worthy of commendation as a fodder, as some of the Australian saltbushes have proved to be. The uncertainty of raising crops in the eastern portions of the state make it desirable to find some plant which will serve the purpose of a good forage and which will grow sufficiently well under the prevailing conditions to produce a fair crop. The people most directly concerned in this have used this native plant; therefore, I undertook its examination.

§146. Its effects upon the sheep, three in number, were not injurious. They seemed to suffer no inconvenience except that they drank a large quantity of water and voided an excessive amount of urine, which had an offensive odor. They otherwise appeared healthy. They ate freely of this hay and chewed their cuds contentedly. If I had made a second experiment and not allowed them to drink so much water, more favorable results might have been obtained.

TABLE LXXIX.

ANALYTICAL DATA FOR THE SALTBUSH, *Atriplex argentea.*

FODDER ANALYSIS.

SALTBUSH.		CORRESPONDING FECES. Sheep No. 4.	
Moisture	5.32	Moisture	6.53
Ash	19.28	Ash	10.53
Ether extract	1.46	Ether extract	1.32
Proteids	9.73	Proteids	6.27
Crude fibre	27.33	Crude fibre	40.44
Nitrogen-free extract	36.88	Nitrogen-free extract	34.91
	100.00		100.00

TABLE LXXX.

ANALYSIS OF THE ASHES.

SALTBUSH.		CORRESPONDING FECES.	
Carbon		Carbon	
Sand	30.097	Sand	43.025
Silicic acid	7.220	Silicic acid	18.718
Sulfuric acid	1.893	Sulfuric acid	0.963
Phosphoric acid	2.838	Phosphoric acid	5.963
Carbonic acid	10.395	Carbonic acid	0.846
Chlorin	6.859	Chlorin	1.576
Potassic oxid	30.980	Potassic oxid	7.944
Sodic oxid	0.073	Sodic oxid	1.316
Calcic oxid	4.730	Calcic oxid	7.548
Magnesic oxid	3.588	Magnesic oxid	6.353
Ferric oxid	0.970	Ferric oxid	1.080
Aluminic oxid	0.443	Aluminic oxid	1.026
Manganic oxid	0.200	Manganic oxid	0.140
Ignition	(1.26)	Ignition	(3.877)
Sum	101.546	Sum	100.355
Oxygen equivalent to chlorin	1.546	Oxygen equivalent to chlorin	.355
	100.000		100.000

ANALYSIS OF THE ASH.

TABLE LXXXI.

ULTIMATE ANALYSIS.

SALTBUSH. Atriplex argentea.		CORRESPONDING FECES.	
Carbon	41.370	Carbon	44.700
Hydrogen	5.581	Hydrogen	5.961
Nitrogen	1.557	Nitrogen	1.003
Sulfur	0.320	Sulfur	0.205
Chlorin	3.965	Chlorin	0.234
Ash	19.280	Ash	10.530
Oxygen (approx.)	27.927	Oxygen (approx.)	37.367
	100.000		100.000

§147. The sulfur and chlorin determinations were made on samples of the fodder, as in previous instances, and not calculated from the ash.

TABLE LXXXII.

SALTBUSH, *Atriplex argentea.*

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	22.243	21.877	22.06
Cold water in 24 hrs. extracted.....	6.777	7.101	6.94
Hot water extracted	5.762	5.852	5.81
Hydric chlorid 1% sol. extracted.....	19.214	19.719	19.46
Sodic hydrate 1% sol. extracted.....	15.734	17.686	16.71
Chlorin, etc., extracted	10.803	9.762	10.28
Cellulose	19.467	18.003	18.74
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	0.88	0.63	0.76
Sucrose in alcoholic extract.....	1.28	1.23	1.25
Gums in cold water extract.....	0.57	0.57	0.57
Starch in hot water extract.....	1.45	1.45	1.45
Xylan in hydric chlorid extract.....	7.48	7.62	7.55
Xylan in sodic hydrate extract.....	2.11	1.67	1.89

TABLE LXXXIII.

SALTBUSH ORTS.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	21.537	21.391	21.47
Cold water in 24 hrs. extracted.....	6.548	6.317	6.43
Hot water extracted	3.239	3.685	3.46
Hydric chlorid 1% sol. extracted.....	17.301	17.450	17.38
Sodic hydrate 1% sol. extracted.....	17.152	17.289	17.22
Chlorin, etc., extracted	11.856	11.857	11.86
Cellulose	22.367	22.011	22.18
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	0.61	0.50	0.56
Sucrose in alcoholic extract.....	1.10	1.13	1.12
Gums in cold water extract.....	0.92	0.70	0.81
Starch in hot water extract.....	1.25	1.18	1.22
Xylan in hydric chlorid extract.....	7.29	7.40	7.35
Xylan in sodic hydrate extract.....	2.37	2.46	2.42

TABLE LXXXIV.

FECES OF SHEEP FED ON SALTBUSH.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	12.802	11.295	12.05
Cold water in 24 hrs. extracted.....	3.248	3.719	3.48
Hot water extracted	3.050	3.023	3.04
Hydric chlorid 1% sol. extracted.....	21.700	22.315	22.00
Sodic hydrate 1% sol. extracted.....	16.902	20.464	18.68
Chlorin, etc., extracted	18.932	15.319	17.13
Cellulose	23.366	23.865	23.62
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	None	None	None
Sucrose in alcoholic extract.....	0.21	0.21	0.21
Gums in cold water extract.....	0.38	0.38	0.38
Starch in hot water extract.....	None	None	None
Xylan in hydric chlorid extract.....	5.03	6.55	5.79
Xylan in sodic hydrate extract.....	4.15	3.47	3.81

TABLE LXXXV.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF SALTBUSH, *Atriplex Argentea.*

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract...	4250.1	682.6	3567.5	1052.8	2514.7	70.49
Total cold water extract..	1337.1	204.4	1132.7	304.1	828.6	73.15
Total hot water and malt extract	1119.4	109.0	1010.4	265.6	744.8	73.54
Total hydric chlorid ext..	3749.2	552.7	3196.5	1922.1	1274.4	39.87
Total sodic hydrate extract	3219.3	547.3	2672.0	1632.0	1040.0	49.00
Total chlorin, etc., extract	1980.6	376.9	1603.7	1496.6	107.1	6.28
Total residue, cellulose ...	3610.5	705.2	2905.3	2063.6	841.7	28.97
	19266.2	3178.1	16088.1	8736.8	7351.3	45.70

The general coefficients obtained for the digestibility of the dry matter were 46.40, 45.84 and 46.50, with the individual sheep; average, 46.25 per cent.

TABLE LXXXVI.

COEFFICIENTS OF DIGESTION FOR THE CARBOHYDRATES IN THE SALTBUSH, *Atriplex Argentea.*

(As indicated by the sugars obtained from the various extracts.)

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose in alcohol extract	146.4	17.8	128.6	0.0	128.6	100.00
Sucrose in alcohol extract	240.3	35.6	204.7	14.6	190.1	92.87
Gums in cold water ext...	109.8	25.7	84.1	32.2	51.9	61.71
Starch in hot water and malt extract	279.4	38.8	240.6	0.0	240.6	100.00
Xylan in hydric chlorid ext	1454.6	233.6	1221.0	505.9	715.1	58.57
Xylan(?) in sodic hydrate extract	364.1	76.9	287.2	332.9	(—45.7)	——

TABLE LXXXVII.

FURFUROL FOUND IN SALTBUSH, *Atriplex argentea*, AND IN THE CORRESPONDING ORTS AND FECES.

	Saltbush Per cent.	Orts Per cent.	Feces Per cent.
Original	9.642	10.488	10.926
Residue after treatment with 80% alcohol	9.642	10.363	10.926
Residue after treatment with cold water	9.058	Same	Same
Residue after treatment with hot water and malt	7.608	10.140	10.440
Residue after treatment with hydric chlorid	4.708	6.036	5.298
Residue after treatment with sodic hydrate	2.570	2.985	3.364
Residue after treatment with chlorin, etc.	2.042	1.216	Not det

TABLE LXXXVIII.

COEFFICIENTS OF DIGESTION FOUND FOR FURFUROL IN THE SALTBUSH, *Atriplex argentea*.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Furfurol in Saltbush	1857.6	333.2	1524.4	954.6	569.8	37.38
Furfurol soluble in 80% alcohol	0.0	0.0	0.0	0.0	0.0	——
Furfurol soluble in water and malt	391.9	9.6	382.3	42.1	340.2	88.99
Furfurol soluble in 1% hydric chlorid	558.7	130.4	428.3	449.6	(—21.3)	——
Furfurol soluble in 1% sodic hydrate	412.0	97.0	315.0	169.0	146.0	46.35
Furfurol soluble in chlorin, etc.	101.7	56.2	45.5			
Furfurol remaining in the residue	393.4	38.6	354.8	293.9	106.4	26.49
			1525.9	954.6	571.3	37.37

TABLE LXXXIX.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS IN THE VARIOUS EXTRACTS OF THE SALTBUSH, *Atriplex argentea*.

Solvent.	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Boiling 80% alcohol	691.7	62.3	629.4	76.1	553.3	87.91
Cold water	57.0	26.7	30.3	45.4	(—15.1)	——
Hot water and malt	108.4	6.7	101.7	37.1	64.6	63.52
1% hydric chlorid	133.1	27.8	105.3	59.4	45.8	43.50
1% sodic hydrate,	618.4	79.5	538.9	161.3	377.6	70.10
Chlorin, sodic hydrate and sulfurous acid	236.4	18.4	218.0	154.5	63.5	29.13
Remaining in cellulose	—29.3	6.8	22.5	22.4	00.1	0.00
	1874.3	228.2	1646.1	556.3	1098.8	66.21

§148. The coefficients of digestion found for the proteids with the three sheep were 67.56, 64.69 and 66.83. The average is 66.36. Bulletin 93, page 38.

METHOXYL GROUP IN THE SALTBUSH, *Atriplex argentea.*

§149. The saltbush hay was examined for the presence of this substance in the same manner that the other fodders were examined. The amount found was 2.104 per cent. I assume that the difference in the amount of this group present in the orts and in the hay is so small that no serious error is made in considering them the same, and I, therefore, made no attempt to determine this group in the orts. The amount in the feces is 2.929 per cent. The total weight of this group consumed was 338.49 grams; the amount voided was 255.90 grams; the amount digested was 82.6 grams, or 24.40 per cent.

§150. Alfalfa, timothy, native hay, corn fodder and the saltbush agree in showing that the substances containing this group are broken down to the extent of about 25 per cent. of the amount present. The result obtained with sorghum was wholly unsatisfactory; though the determination of this group in the feces, corresponding to the sorghum, was made three times and in the sorghum itself twice, with satisfactory agreement in every case. The result, however, indicates that fecal matter may yield this group or, perhaps, it is safer to interpret it that the substances containing this group in the case of sorghum are not digested at all, and that the excess of methoxyl in the feces is due to some error in our determination which we failed to detect, even though we repeated it.

AMID NITROGEN.

§151. The amid nitrogen found in the saltbush hay corresponded to 4.180 per cent of proteids, while that in the orts represented only 1.556 per cent. of proteids. We failed to find any in the feces. As we usually interpret these results, the amid nitrogen was wholly digestible, or has a coefficient of 100.00 per cent.

THE FUEL VALUE OF SALTBUSH, *Atriplex argentea.*

§152. The total dry matter consumed by the sheep in five days was 15,253 grams. We found the calorific value of this dry matter to be 3,886 calories per gram, or a total of 59,273,158 calories. The dry matter in the feces was 8,200 grams, with a heat value of 4,398 calories per gram, or a total of 36,063,600 calories. The sheep, accordingly, appropriated 23,224,811 calories, or 39.16 per cent. of the fuel value—the lowest coefficient of all the fodders used.

§153. The amount of urine voided in this instance was so ex-

ceptionally large that it certainly ought to have been collected, weighed and examined, at least the nitrogen determined. The animals' systems were certainly flooded by the large amount of water drank, 196 pounds in five days, which is a little more than three times as much as the same sheep drank when fed on alfalfa hay and over four times as much as when fed on timothy hay. The heat required to raise this quantity of water from the temperature at which it was drank, 14.5° C., to the the body temperature, taken as 101° F., would be 2,014,387 calories. So large a factor as this must have considerable influence upon the effects produced by the fodder, aside from the lively diffusion induced by the presence of an unusual quantity of water in the system.

TABLE XC.

The dry saltbush hay had the following approximate composition:

Solvent.	Per cent.
Boiling 80% alcohol	17.681
Cold water, 24 hours digestion	7.329
Hot water and malt extract	6.133
One per cent. hydric chlorid	20.560
One per cent. sodic hydrate	17.649
Chlorin, sodic hydrate and sulfurous acid	10.860
Residue, cellulose	19.788
	100.000

TABLE XCI.

THE FUEL VALUES OF THE SALTBUSH HAY AND THE RESPECTIVE RESIDUES.

Dry Saltbush, Atriplex argentea hay	3886 calories
The residue after extraction with 80% alcohol	3986 calories
The residue after extraction with cold water	4284 calories
The residue after extraction with hot water and malt	4346 calories
The residue after extraction with 1% hydric chlorid	4854 calories
The residue after extraction with 1% sodic hydrate	4712 calories
The residue after extraction with chlorin, etc.	4458 calories

TABLE XCII.

THE HEAT UNITS REMOVED FROM ONE GRAM OF SALTBUSH HAY BY THE VARIOUS SOLVENTS.

Boiling 80% alcohol	565 calories
Cold water, 24 hours digestion	108 calories
Hot water and malt extract	220 calories
One per cent. hydric chlorid	649 calories
One per cent. sodic hydrate	900 calories
Chlorin, sodic hydrate and sulfurous acid	558 calories
The residue, or cellulose	886 calories
	3886 calories

TABLE XCIII.

THE FUEL VALUES OF THE RESPECTIVE EXTRACTS OF THE SALT-BUSH, *Atriplex argentea*.

One gram of the alcoholic extract	3196 calories
One gram of the cold water extract	1474 calories
One gram of the hot water and malt extract	3587 calories
One gram of the hydric chlorid extract	3157 calories
One gram of the sodic hydrate extract	5099 calories
One gram of the chlorin, etc., extract	5138 calories
One gram of the residue, cellulose	4458 calories

TABLE XCIV.

THE DRY FECES GAVE THE FOLLOWING EXTRACTS AND RESIDUE.

Solvent.	Per cent. Dissolved.
Boiling 80% alcohol	6.278
Cold water, 24 hours digestion	3.711
Hot water and malt extract	3.235
One per cent. hydric chlorid	23.452
One per cent. sodic hydrate	19.909
Chlorin, sodic hydrate and sulfurous acid	18.249
Residue, cellulose	25.166
	100.000

TABLE XCV.

THE FUEL VALUES OF THE DRY FECES (*Atriplex argentea*) AND THE RESPECTIVE RESIDUES PER GRAM.

The dry feces	4398 calories
The residue after extraction with 80% alcohol	4323 calories
The residue after extraction with cold water	4334 calories
The residue after extraction with hot water and malt	4379 calories
The residue after extraction with 1% hydric chlorid	4371 calories
The residue after extraction with 1% sodic hydrate	4801 calories
The residue after extraction with chlorin, etc., cellulose	4398 calories

TABLE XCVI.

THE HEAT UNITS REMOVED FROM ONE GRAM OF FECES BY SUCCESSIVE TREATMENT WITH THE RESPECTIVE SOLVENTS.

Boiling 80% alcohol	346 calories
Cold water, 24 hours digestion	151 calories
Hot water and malt extract	101 calories
One per cent. hydric chlorid	715 calories
One per cent. sodic hydrate	1002 calories
Chlorin, sodic hydrate and sulfurous acid	976 calories
Remaining in the residue or cellulose	1107 calories

TABLE XCVII.

THE FUEL VALUE OF THE RESPECTIVE EXTRACTS OF THE FECES PER GRAM.

Alcoholic extract	5510 calories
Cold water extract	4069 calories
Hot water extract	3122 calories
One per cent. hydric chlorid extract	3049 calories
One per cent. sodic hydrate extract	5033 calories
Chlorin, sodic hydrate and sulfurous acid extract	5347 calories
The residue or cellulose	4398 calories

TABLE XCVIII.

COEFFICIENTS OF DIGESTION FOR THE HEAT VALUES OF THE VARIOUS EXTRACTS OF THE SALTBUSH (*Atriplex argentea*) HAY.

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Eighty per cent. alcohol extract	8,619,612	2,837,650	5,781,962	67.07
Cold water extract	1,647,934	1,236,976	410,956	24.94
Hot water and malt extract	3,657,432	827,330	2,530,102	75.37
1% hydric chlorid extract	9,900,352	5,863,227	4,037,125	40.78
1% sodic hydrate extract	13,721,409	8,218,889	5,502,520	40.09
Chlorin, sodic hydrate and sulfurous acid extract	8,508,528	7,999,112	509,416	5.99
The residue or cellulose	13,449,786	9,077,472	4,372,314	32.51
	59,205,051	36,060,656	23,149.533	39.12

§154. The coefficient obtained by using the composite samples of the hay and feces was 39.16 per cent., the same as we here obtain by calculation from the values obtained for the various extracts and the analysis of the fodder.

§155. The ordinary fodder analysis indicates no reason why this saltbush hay should not be, at least, a fairly good fodder. There is present more crude proteids than in the average hay, as much nitrogen-free extract as in alfalfa hay and less crude fibre than in alfalfa hay, timothy hay, native hay or corn fodder. The only abnormally abundant constituent is the ash, which amounts to nearly one-fifth of the weight of the dry hay, but three-tenths of this is sand. This amount though large is less than is found in the dried leaves of the sugar beet which are fed with excellent results, to both cattle and sheep. The percentage of ash in the dried beet leaves, not including the crown, ranges from 23 to 27 and to even more than 30 per cent. in the leaves of fodder beets. In this saltbush the ash was found to be 19.28 per cent., somewhat less than the amount found in our sugar beet leaves. The analysis of this ash shows less chlorin, sulfuric acid and soda than the ash of the beet leaves and no more soda than the alfalfa ash. The results of the feeding experiment were, however, not favorable, as each of the three sheep lost weight, one sheep lost one-half pound, one two pounds, and the third six pounds. This loss of six pounds may have been due to the individuality of the sheep more than to the fodder, but aside from this the results in the other two cases show that the fodder is a very poor one. The coefficients of digestion obtained for these groups of food elements, *i. e.*, the ash, proteids, crude fibre and nitrogen-free extract, show some extreme differerences, *i. e.*, the coefficient of digestion for the crude fibre as shown by the three sheep was 6.02, 15.35 and 3.49 respectively, and the sheep with which we obtained a coefficient of 15.35 per cent. was the

one that lost the most, six pounds in five days. The crude proteids, on the other hand, show the highest coefficients of digestion obtained except for the proteids contained in the alfalfa. The total proteids digested by the three sheep fed on alfalfa hay with a gain of nine pounds was 1325 grams, the proteids digested by the sheep fed on the saltbush hay with a total loss of eight and one-half pounds, was 1090 grams, a difference of 235 grams in the weight of the proteids digested. The coefficient obtained for the nitrogen-free extract was very low, 49.16, whereas it was practically 73 in the case of the alfalfa whose nitrogen-free extract has a very high coefficient of digestion. The percentage of the nitrogen-free extract present in the hay is about the same as in alfalfa hay; that for the crude fibre is somewhat lower than in the other fodders forming the subjects of this study, but the percentage of ash is decidedly higher than even the alfalfa and has a very high coefficient of digestion, 71.55, against 57.67 for the alfalfa ash. The high percentage of ash found for the saltbush hay is partly due to the presence of a great deal of sand amounting to 30 per cent. of the ash. The high coefficient of digestion for the ash is fully accounted for by the fact that the base occurring in the largest quantity is potash, making over 75 per cent. of the bases present. The potash is very largely absorbed by the system while lime and magnesia are absorbed by the system in small quantities and these make up the rest of the bases. It is to be noted that in this saltbush so good as no soda salts are present in its ash, only 0.073 per cent. sodic oxid. I have already made mention of the fact that this fodder caused the animals to drink very freely, as much as 15 pounds of water a day, which is very much more than they drank when fed on other fodders, ten times as much as the minimum that the same sheep drank when fed on timothy hay and twice as much as the maximum when fed on alfalfa hay.

§156. If we take up what I have designated as the proximate analysis of this saltbush, *i. e.*, the relative amounts dissolved out of the fodder by treating it successively with 80 per cent. alcohol, etc., we find that it is quite unlike the other fodders, but approaches most nearly to timothy hay, from which it differs in two respects, *i. e.*, in having somewhat less cellulose and in the amount of material removed by chlorin which is much larger than in the case of timothy or any of the other fodders.

§157. This timothy hay proved to be a poor fodder, each of the sheep losing flesh while receiving it as an exclusive ration. The results with the saltbush were very uneven, one sheep lost but one-half pound in the five days, another lost six pounds. I take it that the saltbush was really bad for the latter sheep, though it ate the hay freely and digested a little more dry matter than the sheep that

lost only one-half pound. The difference in the loss cannot be attributed to this sheep's having drunk more water than the other, for it drank less by a few pounds, so that the disturbing influence of an excessive amount of water would probably not be greater in the one case than in the other.

§158. The portion removed from the fodders by treatment with chlorin and subsequent washing with sodic hydrate and sulfurous acid, is usually small, but amounts to 10.28 per cent. in the saltbush. The coefficient of digestion found for this portion is always low. In this case it was found to be only 6.28 per cent. The low coefficient for this portion may be more apparent than real. The percentage of it present in the feces is always comparatively high, in some cases exceeding the amount consumed. This may be, and probably is due to fecal matter, a large percentage of which is removable by this chlorin treatment, which of course would lower the coefficient found, even to the extent of reducing it to zero or showing, as is the case of some extracts, that there was more voided than was ingested.

§159. The sucrose determination in several of the fodders is rendered very doubtful, almost certainly erroneous, by the fact, as the investigation shows conclusively, that some of the substances which yield furfurol are taken into solution by alcohol and presumably yield a reducing sugar when the extract is inverted by heating with dilute acid. This doubt does not attach to the glucose, as this determination does not involve the inversion of the solution, unless such may have taken place during the repeated boilings with alcohol or during its evaporation, which was done on the water bath to avoid either local or general overheating.

§160. The fact that the alcoholic extract of the feces, corresponding to the saltbush, shows the presence of some substance equivalent to 0.21 per cent. of sucrose cannot be taken as conclusively showing the presence of sucrose, but merely that the extract contains some material susceptible of yielding a reducing power equal to this. In the case of corn fodder and sorghum, especially as a saccharine variety was used, the presence of some sucrose in the alcoholic extract of the fodder was to be expected, but the feces corresponding to these fodders yield no sucrose to the boiling 80 per cent. alcohol. The same doubt attaches itself to the starch determination that has been mentioned in connection with the sucrose, *i. e.*, we have depended upon boiling the fodder with water for one hour, cooling it and adding malt extract to bring the starch into solution, but we observe that this process removes enough furfurol in every case in which any starch was found to raise a question as to whether the reducing power was due to inverted starch or to a pentosan.

§161. The sugar found in the hydric chlorid extract of the saltbush and in the other fodders is probably xylose, except in alfalfa in which case the mucic acid found is very nearly equal to the sugar obtained by the Fehling solution and only a small portion can be attributed to xylose. My results with corn fodder are not satisfactory, but the four tests made agree in showing the presence of some mucic acid. In this case we know that both glucose and sucrose were present and whether their presence may have given rise to a mistake or not may be a question. Assuming that they did not, it would appear that other hexoses as well as pentoses are present in this fodder. In this event, the three fodders, alfalfa hay, corn fodder, and saltbush hay, are quite unlike and we find the coefficients of digestion for the sugars formed by the thorough inversion of the hydric chlorid extract to be 83.96, 89.22 and 58.57 respectively, which would indicate that the source of this sugar is different in the saltbush form than in the other two fodders. As already stated it is probably due to galactan in the alfalfa and possibly to both hexose and pentose groups in the corn fodder. The digestibilty of the hydric chlorid extract, that is all that this reagent dissolves out of these fodders, is nearly the same in the alfalfa and corn fodder, 60 per cent. in the former, and 63.88 per cent. in the latter, but it is only 39.88 per cent. for that of the saltbush.

§162. The furfurol has been considered as such and no attempt has been made to specify the particular source from which it was derived. The amount consumed in the different fodders varied from 1030 to 1526 grams and the coefficients of digestion found varied from 37.37 in the saltbush to 65.15 in the alfalfa. If there is any relation between the digestibilty of the furfurol and the value of the hay it is a very general one. The merits of the six fodders used in this study were as follows: Alfalfa, very decidedly the best, corn fodder and native hay standing next, timothy hay next, with the sorghum and saltbush standing far behind the others. The coefficient of digestion of the furfurol in these fodders was found to be as follows: Alfalfa, 65.15, native hay 50.97, corn fodder 47.07, timothy hay 50.13, sorghum 46.46 and saltbush 37.37 per cent. A study of the amount of furfurol removed by the successive treatments to which the hays and fodders were subjected establishes the fact that they deport themselves somewhat differently, the saltbush showing the same amount, relatively, after as before extraction with alcohol, while the other samples showed a decided loss. That extraction with cold water should remove a little furfurol would be expected, provided the material removed and susceptible of inversion is really due to gums. We, however, find that it is uniformly small, as is also the case with the hot water and malt

extract. The two reagents that remove the greater portions of the furfurol are the hydric chlorid and sodic hydrate, but the cellulose often contains as much as either of these. The distribution of the furfurol in the various extracts of alfalfa, the saltbush and corn fodder, may be restated to make clear these differences.

TABLE XCIX.

	Alfalfa Grams	Corn Fodder Grams	Saltbush Grams
Furfurol soluble in 80% alcohol	144.5	1341.4	0.0
Furfurol soluble in 1% hydric chlorid	202.4	590.3	428.0
Furfurol soluble in 1% sodic hydrate	218.2	316.3	315.0
Furfurol remaining in the cellulose	256.2	162.9	400.0*

§163. These results point to very great differences in the properties of the compounds yielding the furfurol. A further study of the different tables will be seen to indicate that the leaves and stems are very different in this respect.

§164. The coefficients of digestibility as indicated by the results obtained point to further differences. We have for the coefficients for the furfurol in the above extracts the following:

TABLE C.

	Alfalfa	Corn Fodder	Saltbush
Soluble in alcohol	96.50	94.80	0.0
Soluble in hydric chlorid	100.00	73.17	Apparently None
Soluble in sodic hydrate	27.18	31.82	46.35
Retained in the cellulose	72.62	32.57	26.49

§165. The coefficient given for the digestibility of the furfurol in the cellulose of the saltbush includes the portion removable by treatment with chlorin, etc. It will be recalled that, in the case of the saltbush, the group which we designate crude fibre has an exceedingly low coefficient of digestion, 15.35 being the highest obtained with either of the sheep.

§166. We will see later that the significance of these differences are quite important. The testimony of the scales in regard to the live weight of these animals is that the alfalfa is an excellent fodder, that the corn fodder is good and that the saltbush is a very poor one. I am fully aware of the importance attached to the nitrogenous substances present in a fodder in the theories of animal nutrition, but the results so far obtained in this experiment, as I interpret them, point clearly to the equal importance of the character of the carbohydrates in the fodder.

§167. The amount and distribution of the proteids in the fodders and their respective extracts have already been given, but we

*This includes the portion removable by chlorin in the above extracts.

bring them together for the three fodders that we have tried to study a little more fully than the others, *i. e.*, alfalfa, corn fodder and the saltbush, *Atriplex argentea.*

TABLE CI.

	Alfalfa	Coefficient of Digestion	Corn Fodder	Coefficient of Digestion	Saltbush	Coefficient of Digestion
The crude proteids consumed.	1817.15	72.92	472.82	37.74	1646.10	66.21
Soluble in 80% alcohol, consumed	594.41	81.69	215.76	65.49	629.40	87.91
Soluble in hydric chlorid, consumed	125.66	59.84	70.07	39.43	105.30	43.50
Soluble in sodic hydrate, consumed	851.70	81.89	98.98	0.00	538.90	70.10
Soluble in chlorin, etc., consumed	39.58	0.00	28.82	46.46	218.00	29.13

§168. We have here very great differences and, if we were to draw conclusions and base them upon the analytical results in regard to the quantity and digestibilty of the proteids present, we would certainly place the saltbush quite close to the alfalfa, but the results of the feeding, expressed in gain or loss of live weight, places the corn fodder far above the saltbush with a gain of 3½ pounds of flesh as against a loss of 8½ pounds or a total difference of 12 pounds live weight. It is only just to add that 6 pounds of the loss chargeable to the saltbush was made by one of the three animals, but even if this be due to the individuality, idiosyncrasy perhaps, of the animal, it suggests that the saltbush may be a bad fodder for many sheep, unless we were unfortunate in getting the one out of many among the three chosen with which it would give particularly unfavorable results. I have elsewhere referred to this possibility and have pointed out that the aggregate loss of the two that did not lose such an exceptional weight, was 2½ pounds, while those fed on corn fodder gained 3½ pounds, so that after assuming that the third sheep receiving the saltbush was so sensitive to its action as to render this sheep wholly unfitted for use in the experiment, the results obtained with the remaining two indicate that this plant is not fitted for a forage plant. The corn fodder, so far as the proteids are concerned, is not so good as the saltbush, but if we consider the carbohydrates as indicated by the sugars obtained in the inverted solutions, or by the furfurol obtained, and their coefficients of digestion, the corn fodder would appear to be much the better of the two, and this is the fact. This view of the importance of the carbohydrates will receive some confirmation when we briefly review the energy supplied by these three fodders and their extracts.

§169. The methoxyl group occurs in all of the fodders, but it is not very abundant, and its coefficient of digestion is low.

§170. The amid nitrogen is not abundant in these hays but its coefficient of digestion is high. How much energy it may yield in its changes either absolutely or in comparison with the albumenoids, I do not know.

§171. Perhaps the most suggestive results are those obtained with the bomb calorimeter. The percentage of heat which disappears from the fodder in its passage through the animal, varies with the different fodders; for the saltbush we found that 39.16 per cent. of the energy had disappeared; for the corn fodder 56.00 per cent., and for the alfalfa 62.43 per cent. In studying the respective extracts, the results agree in showing that the alcoholic extract furnished the largest amount of heat. Next to this in the case of the alfalfa and the saltbush comes the sodic hydrate extract, but in the corn fodder, the residue or cellulose furnishes the second largest quantity. The third largest quantity is furnished in the case of the alfalfa and saltbush by the cellulose and in the corn fodder by the hydric chlorid extract, as shown by the following statement of the heat units appropriated by the sheep from the respective portions:

TABLE CII.

	Alfalfa	Corn Fodder	Saltbush
Alcoholic extract yielded	10,737,717	7,027,781	5,781,962
Sodic hydrate extract yielded	8,218,319	2,146,018	5,502,520
Hydric chlorid extract yielded	2,999,157	4,914,158	4,037,125
Residue or cellulose	5,952,562	5,435,160	4,372,314

§172. These results are quite consonant with those obtained from the study of the extracts which show that the respective fodders yielded the following quantities of digestible material in grams:

TABLE CIII.

	Alfalfa	Corn Fodder	Saltbush
Alcohol extract	2520	1789	2515
Hydric chlorid extract	912	1245	1274
Sodic hydrate extract	1359	342	1040
Residue	1442	1210	841

§173. The fuel value of these different portions are not equal and the coefficients of digestion are also unequal, so that a close agreement could not be expected. The general deportment of the timothy and native hay would seem to place them close to corn fodder. The sorghum shows a large amount of digestible alcoholic extract, hydric chlorid extract and cellulose, but less of the latter two than the corn fodder and though they seem to be large enough in quantity and fairly proportioned, the sheep lost weight amount-

ing to almost three pounds each while being fed on this sorghum fodder.

§174. The amount of residue or cellulose digested in the various trials, the comparative uniformity of the coefficient of digestion and fuel value, indicate a very considerable food value for this portion of the fodder. It is the only portion of the saltbush that was not digested in the usual quantity. The general coefficient obtained for the crude fibre was only 8.29 in which is included the portion soluble in chlorin. When we consider the fuel value of this cellulose, it is higher, by a little, than that prepared from the other fodders, but the coefficient of digestion is very low, only 32.51 per cent. But it is higher than the coefficient found for the crude fibre of this hay, in fact it does not agree at all, except in that it is much lower than the coefficients which we found for this portion of the other fodders. The energy of the saltbush is, in general, low. The amount of water drunk was large and the animals were permitted to drink whenever they wished to. These two things may have interfered with the digestion of the cellulose, *i. e.*, there may not have been enough energy available to effect its breaking up and to carry on the other bodily functions.

DISCUSSION OF RESULTS AND RECAPITULATION

§175. In Bulletin No. 39 of this Station, I attempted to find some way to examine a fodder which would give us more satisfactory information regarding the value of the fodder than the old method furnished. I designated it as "A Study of Alfalfa and Some Other Hays". It is now ten years since that bulletin was published and I here present a brief review of the further work done in this line, extending it very materially to include the distribution of the nitrogen in the different extracts and also that of the pentosans. Further the determinations of the fuel value of the fodders and residues obtained by exhausting the fodders with different menstrua and therewith the energy value of the extracts themselves have been added.

§176. The analytical work has been supplemented by digestion experiments made with sheep, using three individuals in each experiment. When I commenced this portion of my study, I scarcely hoped to be able to carry it to the extent that it has been carried; had I foreseen the end, I would certainly have collected the urine and included this factor in the work, but even then the work would have been incomplete, though it would have been a little more satisfactory than it is at present.

§177. It is not expected that everybody will find interest enough in this subject to lead them to read all of the analytical results to see what errors have been made, and to weigh the force of each individual result obtained, so I may be pardoned for giving, in the form of a recapitulation, a general statement of the work.

§178. The fodders studied are alfalfa hay, timothy hay, native hay, saltbush hay, *Atriplex argentea,* corn fodder and sorghum fodder.

§179. It seems superfluous to state that we used the best quality of these different fodders that we could obtain. The alfalfa was probably rather old when cut and the hay had been preserved in a stack, so that some of it was not in prime condition, but, with these two reservations, it would be classed as very good hay.

§180. The timothy hay was grown in the mountains and was as good a quality as we could obtain. The native hay was, as is all the hay to which this name is applied, a mixture of grasses and sedges, and the results obtained with one sample of it will apply only in a general way to any other sample.

§181. The saltbush, *A. argentea,* was included in this study mainly because we need a plant to use in the eastern portion of the State as a forage plant. Irrigation is out of the question in this

section of the State, and the rainfall is so light that ordinary forage plants do not furnish much forage, if they succeed in living. This saltbush grows abundantly some seasons and in some places, and the ranchmen have cut it, made it into hay and used it to feed their stock during severe storms when the cattle were unable to graze on the plains, and needed something to enable them to endure the storms which, I understand, are often severe, being accompanied by low temperatures and high winds.

§182. I do not know that anyone has observed the effects of this fodder under any conditions, favorable or otherwise, so that our observations and results will be of commercial interest to this section of the State whether they are favorable or not. Further, the saltbushes have not been studied, not even the Australian saltbush, *Atriplex semibaccata,* which is a very different and, as a fodder, I hope, a much more valuable plant than this. It has, at least, been recommended by the California Experiment Station and in a preliminary feeding experiment made by myself it promised to be a fair fodder even when fed alone.

§183. I desired to study the composition, digestibility and feeding value of this class of plants, so this native saltbush which had already been used as a substitute for our better known forage plants, seemed to me to be a subject which would answer my purpose very well indeed, and might possibly be of considerable benefit to the State. I regret that my results do not justify any hope of adding a good forage plant in this indigenous saltbush. As a subject for the study of the questions discussed in this bulletin, however, it serves my purpose very well, for it proves to be a very poor fodder, one scarcely fit to be used under any circumstances and certainly not fit for use under conditions of stress and with cattle already reduced in vitality by continued exposure and lack of a generous supply of food.

§184. This fodder probably contains nothing positively poisonous or injurious, it is simply deficient as a fodder. One of the three sheep experimented with lost only one-half pound but another lost six pounds. We will later try to point out wherein it is deficient. None of the fodders studied serve better than this saltbush to make clear our principal object in this work, *i. e.*, to discover, if possible, what causes the difference between fodders—why one is a good fodder and another a poor one—to discover some way of judging correctly whether a fodder is good or poor without having to feed it, but this is after all, a comparatively convenient, rational and conclusive method and the results obtained by it need no summing up except as to cost.

§185. The other fodders studied were corn fodder and sorghum fodder. The results obtained with these fodders, particularly

in feeding them, were wholly unexpected,in that the former gave better results than was anticipated and the latter very unfavorable ones, which was contrary to what I had expected. Even now, I am scarcely content to accept the results of our feeding experiment. As will be seen subsequently, there is nothing in the composition, judged either by the regulation fodder analysis, or by what I have called the proximate analysis, or in its fuel values to suggest an inferior value for this sorghum fodder, but each of the three sheep fed on this fodder lost very nearly three pounds in five days during which time they not only consumed but digested a very fair amount of food, three pounds per hundred weight of animal daily.

§186. Our object was primarily to study the fodders to find out how we might learn more about the reasons why fodders are so different in value. The groups into which we have been accustomed to divide fodders are not definite groups, but are the best that we have had and they have not yet been displaced. Students have long felt that the results left much to be desired and have adopted other methods of investigation, in order to find out the value of the fodders, their composition, the heat values of the components, and the energy actually furnished to the animal.

§187. It occurred to me that an endeavor to study the carbohydrates might add something to our present knowledge and I chose the line of work presented in Bulletin No. 39, but I realized that it was only an attempt and left much that was unsatisfactory. Some of the results were not concordant and the work was not carried far enough and was not accompanied by any results obtained by these lines of examination in combination with feeding tests, the results of which should serve as facts on which to base our interpretations. I have tried to obviate these faults in the investigation now presented.

§188. I have adhered to the general line of experimentation outlined in Bulletin No. 39, so that the present work may properly be considered a continuation and extension of that. The general method of examination was to exhaust the fodders with boiling 80 per cent. alcohol, cold water, boiling water and after cooling with malt extract, boiling 1 per cent. hydric chlorid, boiling 1 per cent. sodic hydrate, and lastly, with chlorin, subsequently washing with 1 per cent. sodic hydrate and hydric sulfite. I have not yet seen any good reason for changing this order of procedure. The results show, however, that it does not effect a division of the fodder into any definite groups. By this I mean that the extracts consist of mixtures of substance whose composition cannot be established in this way. I hoped, for instance, to be able to determine the sucrose in the alcoholic extract, but I find from the determinations of the furfurol removed from the fodder, that it is quite probable that the

alcoholic extract contains pentosans which may yield reducing sugars on heating with dilute acids, or inversion, so there is doubt whether sucrose, ordinary cane sugar, in a fodder can be determined in this way, especially when present in small quantities. The same is true of the starch determinations, because we found that boiling for one hour and treating with malt extract removed furfurol as in the preceding instance. This shows that the pentosans are dissolved by a considerable range of solvents. Further, we find them present in all of the extracts except possibly that obtained by the treatment with chlorin and subsequent washing with sodic hydrate and sulfurous acid to remove the products of chloridization. Some furfurol is removed from the crude fibre by this treatment but we did not find any reducing sugar in the extract obtained; it is, of course, possible that the action of the chlorin was so drastic that it oxidized and radically changed the furfurol yielding substances so that there remained no hydrolizable carbohydrates of this type in the extract. The residue left, after all these treatments, the cellulose yields from 1.6 to 2.1 per cent. furfurol, showing that substances yielding from one-sixth to one-third of the total furfurol yielded by the fodder, resist all of these treatments and constitute a portion of the cellulose thus obtained. This is probably oxycellulose which may be the source of the furfurol removed by the treatment with chlorin and the subsequent washings.

§189. Again, we find that the nitrogen content of the fodder is distributed unevenly throughout the extracts, some of it, a very little, escaping all of the solvents and remaining in the cellulose. The compounds corresponding to the amid-nitrogen are quite easily soluble and might readily pass into the 80 per cent. alcohol solution, but we find in the case of the alfalfa, for instance, that one-third of the nitrogen, calculated as proteids, is soluble in this menstruum, whereas, the amid-nitrogen, provided it were wholly soluble in 80 per cent. alcohol, could not constitute more than one-fifth of the total, showing that large amounts of nitrogenous substances other than amids went into solution. These statements will suffice to make clear the meaning of the assertion that this procedure does not effect the division of the fodder into well defined groups, and it was not expected that it would, but rather that it might enable us to find differences between the fodders which would at least help to explain the differences observed in their feeding values.

§190. It is and has been known, for the past twenty-four hundred years, that alfalfa hay is a good fodder, so there is nothing new in such a statement. The new thing is the general recognition of the fact and the interest taken in it. I have acknowledged this very generally accepted estimate of the value of this fodder in choosing it as the standard of comparison in this work. It may

not be a good standard for the comparison of all hays, as only a few of our hays are made from this class of plants, *i. e.*, the pea vine, the clovers, etc., even in my work it stands alone, a leguminous hay, though pea vine and red clover hay were included in the work presented in Bulletin No. 39. As a standard of value for different hays made from grasses it may not be a good one, but as a standard of value in this study no better one could, in my opinion, be adopted. It is a favorably known fodder, yielding good results wherever used and its use is rapidly becoming more extensive than heretofore. The results of our investigation of this hay show the following points of interest: But little danger in its use, the green plant may produce bloating in cattle and the feeding of musty and dusty alfalfa hay is charged with producing the heaves in horses, further when fed alone it produces looseness of the bowels and increased urination. These are the evils chargeable to this plant; the rest to be said is favorable, it being an excellent fodder, even for horses when fed with proper precautions, while for fattening cattle and sheep it is unexcelled. For these good reasons, I have chosen it as the first subject for study.

§191. The average composition of this hay is now very generally known; it is characterized by the presence of a high percentage of nitrogen, commonly expressed in terms of crude proteids which usually range from 12 to 15 per cent. of the hay. The group indicated by the term crude fibre is rather abundant, being from 30 to 35 per cent. in good hays, and that understood by the term nitrogen-free extract, is about the same, 30 to 35 per cent. In a general way, then, we may represent alfalfa hay as being composed of one-third crude fibre, one-third nitrogen-free extract, one-sixth proteids while the other sixth is represented by ash and ether extract. The other leguminous hay, common in some parts of Colorado, is pea vine hay. This is, when cut in full bloom, somewhat richer in proteids, with about the same, perhaps a little smaller, percentage of crude fibre and nitrogen-free extract. Red clover hay is occasionally met with and is, so far as the observations of this department go, something richer in nitrogen-free extract, but otherwise about the same as alfalfa. The leguminous hays differ from those made from grasses in that they contain less nitrogen-free extract, 30 to 36 per cent., in samples of alfalfa, third cutting, occasionally as much as 41 per cent., against 42 to 50 per cent. in the hays made from grasses. They are richer in crude fibre, ranging from 32 or 33 to occasionally 40 per cent. for alfalfa against 20 to 30 and sometimes more in the hays of the grasses. They further contain from two to three times as much crude proteid—from 11 to 17 or 18 per cent. against 5 to 9 per cent., rarely more, in that made from the grasses. Such are the differences between the two

classes of hays as shown by the ordinary fodder analyses.

§192. The differences between the hay of leguminous plants and that of grasses is further shown by the large portion removed by simple solvents such as water and alcohol. The total amount dissolved out of the air-dried hays by 80 per cent. alcohol and water in the order followed in this work is for alfalfa, 40 per cent.; red clover hay, 35 per cent.; pea vine hay, 34 per cent.; timothy hay, 31 per cent.; native hay, 30 per cent.; corn fodder, 37 per cent.; sorghum, 47 per cent., and the saltbush experimented with, 28 per cent. The 80 per cent. alcohol extracts from these air-dried fodders and hays, the following amounts: From alfalfa, 27 per cent.; corn fodder, 29 per cent.; timothy hay, 21 per cent.; native hay, 21 per cent.; sorghum, 36 per cent., and from the saltbush hay, 22 per cent. A quantity of alfalfa was digested with cold water for 24 hours and the loss then determined, when it was found to be 40 per cent. Apparently then, water alone will remove from alfalfa as large an amount of extractives as alcohol and water when used successively; this was not established by repetitions of this experiment. No precaution was taken against fermentative changes. This result is consonant with the well known susceptibility of alfalfa to injury by moisture, even a heavy dew sufficing to discolor it. I did not submit the hay to the ordinary fodder analysis after treating it in this manner. The results would doubtlessly have been interesting if I had done so, but I have an old analysis of a hay damaged by a succession of showers necessitating the exposure of the hay to both extraction and fermentation. Making no allowance for the large loss of weight, which must have been suffered in this case, we have the following difference in the hay as cut and gathered: Crude fibre as cut 26.46 per cent., as gathered 38.83 per cent.; crude proteid as cut 18.71 per cent.; as gathered 11.01 per cent.; and the nitrogen-free extract 38.91 per cent. as cut, and 33.64 per cent. as gathered. These results are affected by the mechanical losses as well as chemical, but they serve to suggest that it is not only an important consideration for the farmer but a good point of attack for the student of such subjects. The hays made from the grasses, and the native hay, being a mixture of grasses and sedges, may in this respect be fairly representative of such as are usually used in hay making, yield just about one-half as much to alcohol and water as the leguminous hays.

§193. The other well known class of fodders represented in our study is corn fodder. The dry matter of this fodder differs according to the ordinary fodder analyses from that of the leguminous hay in containing nearly one-half more nitrogen-free extract, and from one-third to one-half as much crude proteid, while the

crude fibre is not far from the same, though not nearly so constant, being sometimes more and sometimes less.

§194. The solubility of the nitrogenous substances of these different fodders in 80 per cent. alcohol may further exhibit their differences, as well as the extent to which these substances are soluble in this medium. The nitrogen has, of course, been calculated as proteids by multiplying by 6.25, the usual factor. The following table gives the weight in grams of the proteids in the fodders fed, and the amount which was soluble in the respective solvents.

TABLE CIV.

	Alfalfa	Corn fodder	Timothy	Native hay	Saltbush
80% alcohol	640.0	249.0	189.0	231.0	692.0
Cold water	91.0	33.0	83.0	70.0	57.0
Hot water and malt	135.0	27.0			108.0
1% hydric chlorid...	127.0	79.0	99.0	98.0	133.0
1% sodic hydrate ...	937.0	116.0	350.0	384.0	618.0
Chlorin	45.0	30.0	13.0	29.0	236.0
Residue or cellulose.	17.0	6.0	9.0	11.0	29.0
Total proteids fed ..	1992.0	540.0	743.0	823.0	1873.0

§195. We see that the two hays, timothy and native hay, yield between one-quarter and one-third of their nitrogen to the alcohol, which is nearly as high a ratio as in the case of alfalfa and the saltbush. The maximum relative portion is observed in the case of the corn fodder in which the amount dissolved amounts to nearly one-half. There is either no relation between the soluble nitrogen and the value of the fodder, or it is so greatly modified by other factors that it is entirely concealed. Of these fodders, alfalfa produced the largest results, *i. e.*, 9 pounds of flesh in five days; the corn fodder and native hay next with 3½ pounds each; the saltbush and sorghum last with a loss of 8½ pounds each.

§196. The amount of nitrogenous matter dissolved out of the hays by water, after previous treatment with the 80 per cent. alcohol is very small, but the loss of the alfalfa hay which has been exposed to the rains suggests, at least, that the nitrogenous matter soluble in the alcohol may also be soluble in water. Be this as it may, neither cold or boiling water removed any very considerable portion after the previous treatment with alcohol. The two exceptions to this are the saltbush and the alfalfa. We also notice that it is these two, saltbush and alfalfa, from which the 1 per cent. hydric chlorid removes the largest quantities of the proteids, that is, absolutely but not relatively, for in the alfalfa, for instance, about one-sixteenth of the nitrogen is dissolved out by the 1 per cent. hydric chlorid, while in the corn fodder and timothy hay it is about one-seventh.

§197. The similarity between the alfalfa and the saltbush in regard to the amount of proteids present and their solubility in these solvents is striking and two things regarding them is very evident, *i. e.*, while one-half of the proteids were removed from the alfalfa by the 1 per cent. sodic hydrate, only one-third of them was removed from the saltbush, but the amount removed by chlorin and subsequent washing with 1 per cent. sodic hydrate and hydric sulfite is five times as great. The relative quantities, owing to the fact that the quantities fed were so nearly alike, are the same, *i. e.*, one-fortieth and one-eighth respectively. The nitrogenous substances removed by the chlorin and the subsequent washings usually amount to but a few grams and are apparently often more abundant in the feces than in the hay or fodder, but in the saltbush hay such proteids(?) are unusually abundant and they have a coefficient of digestion, according to our experiments, of about 29 per cent., which is, of course, very low. We evidently have to do with nitrogenous substances quite different in character and while our division of them into groups is not satisfactory, we still have three big groups, those removed by 80 per cent alcohol, always with a good or even high coefficient of digestion; those soluble in hydric chlorid differing very much in their digestibility, from 39 to 63 per cent. in the different fodders, and those soluble in sodic hydrate which have high coefficients of digestion, except in the case of the corn fodder in which this group of nitrogenous substances is not nearly so large as in the other fodders and is, apparently, so good as indigestible. The proteids soluble in cold and hot water are not considerable in quantity, except in the alfalfa and saltbush, and are not very digestible, while those removed by chlorin, etc., are small in quantity, except in the case of the saltbush, in which they constitute an eighth of the total, and either show a low coefficient of digestion, 29 per cent. in the case of the saltbush, or are more abundant in the feces than in the fodder fed.

§198. What the bearing of these facts may be on the feeding values or properties of the fodders is not clear.

§199. It may be well to consider some facts, as well as we may, but without assuming that we know anything about them. The alfalfa and saltbush, for instance, constitute the extremes in our series of fodders, perhaps I should, to be logical in interpreting our results, class sorghum and saltbush together. As already stated, I cannot but entertain a strong opinion that the sorghum should be studied further, because of the very unfavorable results obtained. It must, however, be acknowledged that the results in the case of the three sheep were uniform and unfavorable, though the fodder was apparently of excellent quality and in very good condition. The results showed a loss of almost three pounds in each of

the three sheep, which certainly ought to have more weight than my opinion that the sorghum is a better fodder than these results indicate. We did not make as full a study of the sorghum as of the other fodders and for these two reasons I have less to say about the sorghum than about the others.

§200. With this explanation regarding the sorghum, I will consider the saltbush as constituting the most inferior fodder of the series, and yet, as stated before, this fodder is richer in proteids than either of the remaining five, alfalfa alone excepted. With the alfalfa, we fed, in round numbers, 2,000 grams of proteids, coefficient of digestion 72.5, with the saltbush practically 1,900 grams, coefficient of digestion 66.4. The three sheep fed on alfalfa gained 9 pounds, those fed on saltbush lost 8½ pounds. It is, of course, wholly improbable that other constituents had no disturbing effects on the results, but it is also very probable that the nitrogenous substances soluble in the different reagents are of very different value and it is not the amount of the proteids (N x 6.25) present, but their character which determines their value. It may be that the large amount of chlorin-soluble nitrogen present in the saltbush, constitutes not only an analytical difference, but a nutritive one also. It is evident that the sheep digested rather more proteids when fed on alfalfa but the difference is not very big, 239 grams. The amounts of proteids digested where corn fodder was fed were quite small, less than one-fifth of that digested in the case of the saltbush and one-sixth of that in the case of the alfalfa. The amount digested when native hay was fed was less than one-half of that digested in the case of the saltbush. Both the native hay and corn fodder proved to be good fodders, all of the sheep gaining while receiving them; the aggregate gain in the two lots of three sheep each, was three and one-half pounds for each lot.

§201. The animals were not fattened on these fodders and killed to see the relation of muscle to fat, so I do not know anything about this feature of their effects. The amount of the alcohol-soluble proteids in the corn fodder is larger than that in any of the other solvents, being 217 grams out of a total of 473 grams. In the case of the native hay the two solvents removing the largest quantities of proteids are the sodic hydrate and alcohol. The contrast in the results produced in these experiments is that the sheep receiving saltbush digested 1,091 grams of proteids and were losing flesh, some of them rapidly; those receiving the other fodders were gaining, though they received much smaller amounts of proteids with either the corn fodder or native hay and only 239 grams more when fed alfalfa, but in this case the lot made a gain of nine pounds against a loss of 8½ pounds in the lot receiving saltbush.

§202. The question which I have tried to present is, do the

facts exhibited by the results of this proximate analysis offer any suggestions regarding the reasons for so great a difference in the feeding values of these fodders.

§203. We will later give a reason for the assertion that the alcoholic extract is the most important portion of the fodder and we observe that the proteids of the saltbush, soluble in alcohol and digestible, is greater even than in alfalfa, so that it would seem probable that this portion of the saltbush, unless it should contain some therapeutically active and deleterious substance, is probably the most valuable portion of this fodder, but if the fuel values are safe criteria, it is of comparatively small value compared with that of the corresponding alfalfa extract, giving a little over one-half the energy. This, of course, applies to the whole extract from which we cannot single out the effect of the nitrogenous matter.

§204. The carbohydrates in the alfalfa and the saltbush are evidently quite different; if we take the total sugars as the measure, they stand as 9 to 26, there having been fed with the alfalfa, carbohydrates capable of giving 900 grams of sugars, while the saltbush gave 2,600 grams. The furfurol also indicates a great difference. There was consumed with the alfalfa 1,030 grams of furfurol and 1,524 grams with the saltbush. The coefficient of digestion for the furfurol in the alfalfa was 65.2, and for that in the saltbush 37.4. The weight of alfalfa fed was 13,351 grams, and of saltbush 16,088 grams. The difference in the coefficients of digestion is also very marked, 37.4 in the case of the saltbush and 65.2 in that of the alfalfa. The difference in the character of the carbohydrates is still further indicated by the low degree of digestibility shown by the residue, which I have for convenience sake called cellulose, which is 29 for that from the saltbush and 53 for that from the alfalfa. The action of chlorin, together with the subsequent washing with sodic hydrate and sulfurous acid does not show as great a difference in these cases as in that of some other fodders, though the amount removed from the saltbush is the greater by about 1.6 pounds per hundred. This portion of the fodder seems to be uniformly very difficult of digestion, the coefficient in the case of the saltbush being but 6.3. I have elsewhere suggested that the low coefficient uniformly obtained for this portion of the fodder may be apparent only, due possibly to a close resemblance between it and fecal matter, as we have found this portion in the feces larger than the total fed in several instances. The hydric chlorid with which the fodders were boiled till no more sugars were produced, also shows a decided difference. The alfalfa consumed, 12,364 grams, yielded but 340 grams of sugar, calculated as galactan, whereas the 16,088 grams of saltbush yielded 1,455 grams of sugar calculated as xylan; here again the coefficients of digestion indicate wide difference of proper-

ties. The alfalfa sugar, galactose, shows a coefficient of 84, and the saltbush sugar, xylose, a coefficient of 58.6.

§205. The nitrogenous substances may contribute a small proportion of these sugars, but they undoubtedly are, for the most part, derived from other compounds.

§206. The difference in the coefficients of digestion for the respective residues becomes still more significant when it is called to mind that this residue is one of the three important portions of the fodder, as will be more fully shown under the discussion of their relative heat values. We will find that the coefficients of digestion, 53 for the residue from the alfalfa and 29 for that from the saltbush, are not consonant with the heat values obtained, but still we will see that they are nearly so and that the saltbush residue yielded less than three-fifths as much energy per unit of weight as that from the alfalfa.

§207. The corn fodder was found to be a good fodder, producing a gain of 3½ pounds in the three sheep. There was digested by the sheep in this instance 4,940 grams of dry matter, equal to 56.3 per cent. of that consumed, 1,789 grams of which was soluble in alcohol, 1,245 grams soluble in hydric chlorid, and 1,210 insoluble.

§208. In this case the sugars indicate the presence of a large portion of alcohol-soluble carbohydrates, glucose and cane sugar, together amounting to 872 grams, which is wholly digestible, and 975 grams in the form of galactan and xylan, sugars inverted by the action of the dilute hydric chlorid; these practically constitute the whole of this class of substances in the corn fodder, as cold water, hot water and sodic hydrate together remove but 100 grams of sugars from the whole amount of corn fodder consumed; the cellulose is, of course, to be added to these to obtain the total carbohydrates. The furfurol removed by alcohol is very small in amount, so that while some pentosans are present the amount is at most, insignificant; 77.5 grams were consumed and the coefficient of digestion was found to be 94.8 per cent., so, aside from our knowledge of the fact that sucrose and reducing sugars occur in the juices of the corn stalk, there is no question but that the sugar found did not come from the inversion of other carbohydrates. The total amount of furfurol found to have been removed by hot water and malt seems to be open to question, as our duplicate determinations did not agree very well. The hydric chlorid extract furnished very nearly one-half of the sugars found and a little more than one-half of the furfurol found in the extracts of the fodder; this, of course, does not include the residue or cellulose.

§209. The amount of proteids consumed with the corn fodder was much less than in the other two instances, alfalfa and saltbush. With the alfalfa 1,817 grams were consumed and 1,325 digested;

with the saltbush 1,646 grams were consumed and 1,090 grams digested; but with the corn fodder there was only 473 grams of proteids consumed and 179 grams digested. This fodder seems to give favorable results, though the composition of the fodder is very different from the others in respect to the amount and character of the carbohydrates and also in regard to the proteids, the latter, in particular, being largely soluble in the 80 per cent. alcohol. This is especially noticeable with the portion digested, as 141 grams out of the 178 digested were soluble in the alcohol. Another point of difference between the proteids of these three fodders is the low degree of digestibility of the proteids contained in the corn fodder. This is true with both the general coefficient and the coefficients obtained for the proteids in the extracts. The general coefficients of digestibility for the proteids are 73 for those of the alfalfa, 66.4 for those of the saltbush, and 36 for those in the corn fodder. Alcohol dissolves approximately one-third of the total proteids out of alfalfa, and these have a coefficient of digestion of 81.7; from the saltbush a trifle more than one-third, and the coefficient of digestion was found to be 88; from the corn fodder, it dissolves a little less than one-half of the nitrogen, calculated as proteids, of which 65.5 per cent. was found to be digestible.

§210. The other solvents removed quite small amounts of proteids from the corn fodder and these have quite low coefficients of digestion. The sodic hydrate dissolves the second largest portion of the proteids out of the fodder, but it is so good as indigestible. This is in marked contrast with the other fodders, in which cases the amounts of proteids dissolved out by the sodic hydrate are both absolutely and relatively much greater, and the coefficient of digestion is high in each case, 82 for that of alfalfa and 70 for that of the saltbush, against zero for that of the corn fodder. It is possible that the coefficient obtained for this portion of the proteids is erroneous, but it is not probable, and it is safe to assume that the coefficient of digestion of this portion of the proteids in corn fodder is very low, indeed, probably zero, as above stated.

§211. The most notable features so far developed are that the soluble carbohydrates, *i. e.*, all that portion of the fodders not included under the proteids, and the residue or cellulose vary within narrow limits, except for those soluble in hydric chlorid. The most important extract is that obtained by alcohol, in which, it is true, that large quantities of proteids occur, but their coefficient of digestion is, in the cases of the saltbush and corn fodder, less than the general coefficient for the extract, so that the coefficient for the carbohydrates must be higher than that found for the extract. This does not hold for the alfalfa. The coefficients of digestion found for the alcoholic extracts of these three fodders are as follows—alfalfa,

68.6; saltbush, 70.5; corn fodder, 73.8. We see that they are quite close together, and as the percentage of the respective fodders soluble in alcohol are not very unlike, it seems just to assume that in the absence of any injurious constituent they have approximately the same value, but such is not the case, as is indicated by the heat values appropriated by the animals, according to which the relative values of the three alcoholic extracts stand as 1 to 1.5 to 1.9 nearly. The alfalfa extract having a value of 1.9 and that of the corn fodder 1.5, if the saltbush extract be taken as 1. The second important division of the carbohydrates is represented by the hydric chlorid extract and here we find very great differences indicated by the coefficients of digestion. This portion of the alfalfa has a coefficient of 60.2; that of the corn fodder 69.4, while that of the saltbush has a coefficient of only 39.9. The percentage of this portion present in these fodders was found to be as follows: Alfalfa, 12.2; corn fodder, 18.9, and saltbush, 17.0. We observe that the coefficient of digestion for this group of substances in the saltbush is low and the percentage of it present in the hay is high, from which standpoint it would be an important factor in judging of the value of the fodder. The coefficients of digestion found for the corresponding heat values were, for the alfalfa, 54.75; for the corn fodder, 63.88, and for the saltbush, 40.7. The indication of these coefficients, too, is that this portion of the saltbush extract is inferior to that of the other two. The heat appropriated by the sheep per gram of this extract consumed, stood in the ratio of 1.3 to 1.8 to 2, the saltbush again being the lowest and the alfalfa the highest. The deportment of the proteids present in these different fodders has been referred to in a previous paragraph, where it is shown, though not explicitly stated, that the proteids in the saltbush resemble those of the alfalfa in their quantity and deportment toward the different solvents, so here we find the proteids in the alcoholic extract of the corn fodders relatively high and those of the alfalfa and saltbush relatively low, but the absolute amount of proteids in the hydric chlorid extract of the corn fodder is small and of no significance, while the actual weight of the proteids dissolved out of the alfalfa and saltbush, respectively, is much greater than in the case of the corn fodder, but it is not sufficiently large to materially modify the statements made relative to the value of the carbohydates represented by this portion of the fodder.

§212. The sodic hydrate extracts of the three fodders differ greatly; that from the alfalfa shows a coefficient of digestion of 67.7, but about 43 per cent of the total extract is proteids (N. x 6.25); that of the corn fodder is poor in proteids and has a coefficient of only 36.3, while that from the saltbush is richer in proteids, about 20 per cent. of the extract consumed being proteids, and has

a coefficient of digestion of 49, but that of the proteids contained in this extract is 70, so that the substances, other than proteids in this extract must have a low coefficient, which is consonant with the result obtained in the case of the corn fodder. The portion of this extract, sodic hydrate, having the greater value is probably the nitrogenous substance, while the carbohydrates possess the lesser value.

§213. None of our results are more instructive probably than those shown by the portion which resists the action of our solvents, even the chlorin followed by the caustic soda and sulfurous acid. We find that this residue from the alfalfa hay has a coefficient of digestion of 52.8, and that from the corn fodder a coefficient of 54.0 per cent. The boiling one per cent. solutions of hydric chlorid and sodic hydrate are pretty active agents, but moist chlorin is much more active, still the animal digestive processes effect the solution of upwards of 50 per cent. of the material in the good fodders, alfalfa and corn fodder, which has resisted these agents, while in the poor fodder, saltbush, these processes are capable of bringing only 29 per cent. of this residue into solution. It will be shown a little later that the heat values show a similar result.

§214. There is no evidence, that I have discovered, that the saltbush had any deleterious effect on the sheep, though I have been told that it acts as a laxative on cattle, and it did induce excessive thirst and urination in the sheep experimented with. There were no indications that the sheep were in the least uncomfortable. While the nitrogenous substances in this forage may be inferior in value to those in the alfalfa, there is no proof that they are. Two things are, however, clear—that they are much more abundant and have a much higher coefficient of digestion than those of the corn fodder; in fact, this fodder approaches the alfalfa in this respect more closely than either of the other fodders used in the experiment, and while I know nothing relative to the fuel value of the nitrogenous compounds, it may be assumed that the differences are not sufficient to completely reverse the indications given by the coefficients of digestion obtained for the proteids, according to which the saltbush should have a very much higher feeding value than the corn fodder, and nearly equal to that of the alfalfa. On the other hand, all of the data obtained indicate that the carbohydrates, whether soluble in the various menstrua or not, are difficultly digestible and, taken all together, are of low fuel value. This is particularly the case with the two important portions, the portion removed by hydric chlorid, 1 per cent. solution, and the cellulose or residue, the former having a coefficient of digestion of 39.9 and the latter of 29.0 per cent., as against 69.4 and 54.0 per cent., respectively, in the corn fodder. The factor in this fodder which seems to determine its feeding value is

the character of the carbohydrates that it contains. The nitrogenous matters contained in the saltbush are abundant and are highly digestible. The carbohydrates are resistant to the processes of digestion. The sheep digested large amounts of protein, 1,090 grams, but relatively small amounts of carbohydrates, and the lot lost 8½ pounds in five days. The results obtained with this fodder are in strong contrast with the other two; with the alfalfa the sheep ate and digested large quantities of both nitrogenous compounds and carbohydrates, both those soluble in hydric chlorid, 1 per cent. solution, and those which resisted the action of all of our solvents; with the corn fodder, they consumed a relatively small amount of nitrogenous compounds, having a low coefficient of digestion, 37.7 per cent., and a relatively large amount of carbohydrates with a high coefficient of digestion. The total amount of dry matter consumed as corn fodder was smaller than with any other fodder used, still each of the animals gained flesh, the lot gaining 3½ pounds in five days.

§215. The urine was not collected in any instance, an omission which is especially regretable in the case of the saltbush, because a large amount of nitrogenous matter was digested and there was a pronounced loss, especially with one of the sheep, 6 pounds. This is the only case in which we found marked differences in the individuals, but we did observe that one of the animals evidently did not like portions of the timothy, and while two of them lost a little, one gained a little, while on an exclusively timothy ration. With the other fodders, they either all lost or all gained. With the alfalfa they each gained three pounds, with the sorghum they each lost about three pounds, with the corn fodder and native hay they each gained, the total gain for each lot being three and one-half pounds.

§216. The other fodders, timothy hay, native hay and sorghum, were not studied to the same extent as those already given. Of these three, the native hay is the only one on which the lot made a gain; one sheep made a gain of one-half a pound on the timothy, but each of the others showed a loss, so that the lot showed a slight loss.

§217. As the same general result, *i. e.*, a gain of three and a half pounds in each case, was obtained with the corn fodder and native hay, we will present the salient points in the character of these fodders so far as we can; the alcoholic extract of the corn fodder furnished 1,789 grams of digestible matter, 73.79 per cent. of the total extract; that of the native hay furnished 1,297 grams, 58.55 per cent of the total; the hydric chlorid extract of the corn fodder yielded 1,245 grams digestible matter, equal to 69.42 per cent. of the extract; that of the native hay 1,422 grams, equal to 64.04 per cent. of the extract; the sodic hydrate extract of the corn fodder yielded

342 grams of digestible matter, equal to 36.27 per cent. of the extract; that of the native hay yielded 575 grams, equal to 32.79 per cent. of the extract; the residue or cellulose from the corn fodder yielded 1,210 grams of digestible matter, equal to 54 per cent. of the residue and that of the native hay yielded 1,502 grams, equal to 50.57 per cent. of the residue.

§218. In the case of the timothy hay, the values of the respective extracts stand in the same order, but the digestible matter furnished in each case, the sodic hydrate extract excepted, is less than in the two preceding cases; the alcoholic extract furnished 1,085 grams of digestible matter; the hydric chlorid extract 1,099 grams; the sodic hydrate extract 733, and the residue of cellulose 932 grams. The digestible proteids (N. x 6.25) in these extracts were determined; in the alcoholic extract there were 129 grams; in the hydric chlorid extract 23 grams, and in that obtained by means of sodic hydrate 136 grams. The digestible proteids in the corresponding extracts of the corn fodder were found to be 141 grams in the alcoholic, 28 grams in the hydric chlorid, and none in the sodic hydrate extract. We see again, in the timothy hay, as in the saltbush, that a larger amount of proteids were digested and a decidedly smaller amount of carbohydrates, the most marked deficiency being in the portion designated as residue or cellulose. The feeding results were a loss in both cases, though with the timothy hay, it was only slight, and one sheep showed a slight gain, but this sheep digested two-thirds more crude fibre than either of the other two. This may, however, be an accident only. The proteids in the various extracts of the native hay were not determined.

§219. The extracts of the sorghum stand in the same order as those of the corn fodder, and the amount of digestible matter contained in the alcoholic extract is much larger, nearly twice as large, but that furnished by the hydric chlorid extract and by the residue or cellulose, furnishes one-sixth less than in the case of the corn fodder.

§220. So far as our analytical results and also the energy values obtained are reliable criteria, sorghum fodder would appear to be a good one, but the results as indicated by the weights of the sheep at the beginning and end of this experiment indicate that it is a poor fodder. The results were uniform, *i. e.,* each of the sheep lost three pounds and the conditions of the experiment were as favorable as we could make them; everything, in fact, was in favor of obtaining good results with this fodder. The weather was fair and moderately cool. The sheep were used to being handled. They fed freely and were allowed a liberal ration, still they lost weight, and the same sheep gained when fed on corn fodder, so that the individuality of the sheep is eliminated so far as this comparison of

the corn fodder and sorghum is concerned. As I have elsewhere stated, any inferences from the analytical results or determinations of the fuel values and all personal opinion regarding the value of such sorghum fodder must be held in abeyance when the feeding results are so strongly against them.

§221. I do not know what the general judgment relative to the value of this fodder is, but Mr. Payne, who grew this sorghum, tells me that he and the party who joined him in his work with this sorghum, came to the conclusion that when fed alone it was of no value, which agrees with the results of my feeding experiments.

§222. The pentosans as represented by the furfurol show very marked differences. The four portions of the fodders which are of the most importance cannot be designated as in the case of the extracts, because they vary with each fodder. The alfalfa was beyond all question the best fodder experimented with, and we find considerable quantities of furfurol in each of the extracts made, but the three most important portions of the hay in furnishing digestible furfurol were the alcoholic and hydric chlorid extracts and the residue or cellulose. The sodic hydrate removed more furfurol from the fodder than any other solvent, but its coefficient of digestion is very low, 27.80 per cent., while the coefficient of digestion for the whole extract was high, 67.7 per cent. Cold water, hot water and malt extract and chlorin, with the subsequent washing with sodic hydrate and hydric sulfite, each remove some furfurol, but the quantities are relatively small and the coefficients of digestion vary greatly, which, owing to the relatively small quantities involved, is probably a matter of small importance. This class of substances, the pentosans, constitute about one-eleventh of the total dry matter digested by the sheep fed on alfalfa, about one-tenth of that digested as corn fodder and about one-thirteenth of that digested as saltbush, which is the smallest amount found in any of the six fodders.

§223. The fodders which stood nearest in value to the alfalfa were the native hay and corn fodder. This does not mean that they were nearly equal to it by any means, but the two fodders giving the next best results measured by the increase in the live weight. The lot receiving alfalfa gained nine pounds, while the lots receiving native hay and corn fodder, respectively, gained three and one-half pounds each. The lot receiving timothy hay lost one pound. The timothy and native hays are representative of the small grasses, as distinguished from the corn fodder, and are more nearly alike so far as the distribution of the pentosans is concerned than the native hay and corn fodder. From the smaller grasses, timothy and the native grasses, the largest quantities of furfurol are removed by the hydric chlorid and sodic hydrate. The next largest portion remains in the residue or cellulose. The coefficients of di-

gestion of the furfurol contained in the respective portions of these hays are very different. The furfurol removed by the hydric chlorid has a coefficient of 32.8 in the case of timothy hay, and 44.04 in the native hay; that removed by the sodic hydrate has a coefficient of 11.54 in the timothy and 42.16 in the native hay, and that remaining in the cellulose has a coefficient of 50.12 per cent. in the timothy and 74.94 in the native hay. The furfurol in some of the other extracts shows higher coefficients of digestion, but owing to the smaller quantities concerned are of less importance.

§224. The amount of furfurol in the cellulose is usually large. In the cellulose from the alfalfa, 235.7 grams; from the timothy, 197.1 grams, and from the native hay, 219.1 grams. The alfalfa and native hays proved to be good fodders, the timothy hay a poor one.

§225. The distribution of the furfurol in the different portions of the corn fodder agrees with that of the hays already mentioned, in regard to the hydric chlorid and the sodic hydrate extracts, but the cellulose shows less furfurol and it has a very much lower coefficient of digestion. In the case of the corn fodder, the hydric chlorid extract shows the largest amount of furfurol, 371.8 grams, with a high coefficient of digestion, 66.25. The sodic hydrate extract consumed contained 236 grams of furfurol, coefficient of digestion 31.82. The next extract in importance, as indicated by the furfurol, was the hot water extract, in which the furfurol was wholly digestible. I have very strong misgivings as to the correctness of this determination and, for this reason, have attached but little importance to it; if, as I surmise, there is an error in this determination, it will increase the relative importance of the hydric chlorid extract. This corn fodder proved as efficient as the native hay in results obtained, *i. e.*, a gain of 3½ pounds live weight in the lot fed, but this lot did not consume as much dry matter by 1,811 grams as the one receiving native hay. The general coefficient of digestion obtained for the furfurol in corn fodder was found to be 60.19 per cent., which does not agree with that obtained by taking the sum of the furfurol found in the different extracts, being about 12 per cent. higher.

§226. It will be observed that on three of these fodders, the respective lots of sheep gained, and on the other three the lots lost. I have already mentioned timothy hay as one in which the lot receiving it lost in weight. The other two were sorghum and the saltbush, *Atriplex argentea*. Regarding the distribution and digestibility of the furfurol, representative of the pentosans, we find that in the sorghum, the three portions, the hydric chlorid extract, the sodic hydrate extract and the cellulose, contain practically the whole of it, and that the furfurol shows the following coefficients of diges-

tion, 45.72, 25.44 and 48.72, respectively. In the saltbush we have to add the aqueous extract to the above. The alcoholic extract removed no furfurol or equivalent pentosan, but both glucose and sucrose were present and the extract was abundant, 3,197 grams of it having been consumed. The next salient feature in this connection is the low coefficient of digestion found for the furfurol, *i. e.*, 37.37; the pentosans extracted by the 1 per cent. solution of hydric chlorid are indigestible in this case, whereas it is highly digestible in the alfalfa and corn fodder and has a coefficient of 44.04 in the native hay. The coefficient of digestion for the furfurol in the cellulose of the alfalfa and native hay is 72.6 and 74.9, respectively, and is very low in that of the corn fodder, 32.57. There is no means of judging how much pith cellulose is represented in this corn fodder, and I know nothing about the deportment of this variety of cellulose. It is quite possible that this may have a noitceable influence on this result. In the three fodders which we find to be inferior or poor, timothy, sorghum and saltbush, we have low coefficients for the furfurol, the general coefficients being 36.24, 46.46 and 37.37, respectively, and for the furfurol in the cellulose 50.12, 48.72 and 26.49, respectively.

§227. I will again call attention to the fact that the cellulose obtained as the result of these treatments has, as a rule, a fairly high coefficient of digestion in those fodders which proved to be the best ones, in alfalfa 52.8, in corn fodder 54.0, in native hay 50.6, but lower in the other three, timothy, sorghum and saltbush, 41.6, 47.4 and 29, respectively. The digestible proteids in these fodders were in the alfalfa 1,325.09 grams, in the native hay 366.55 grams, and in the corn fodder 178.46 grams; these are the three fodders which caused the sheep to gain, the other three, timothy, sorghum and saltbush, caused them to lose. The following amounts of proteids were digested while the sheep were on these fodders, with the timothy 234.42 grams, with the sorghum 300.91 grams, and with the saltbush 1,089.80 grams, so that the loss is scarcely to be attributed to a lack of digestible proteids. The sheep digested almost as many grams of proteids with the sorghum as with the native hay and almost 1½ times as much as they digested in the form of corn fodder. They digested six times as much in the form of saltbush as in that of corn fodder, and while the one lot gained 3½ pounds on the corn fodder, the other lot lost 8½ pounds on the saltbush. My interpretation is that the differences in the results point to the absence of a sufficient amount of easily digestible carbohydrates in the timothy hay, sorghum and saltbush.

§228. I have in mind a little more definite idea when I use the term easily digestible than we sometimes have when we use this term. I do not simply mean that large quantities of the carbohy-

drates are taken up and a condition of comfort and general well being produced in the animal, but that the amount of energy necessarily used up in carrying on the animal functions while on the fodder and that used up in transforming the fodder constituents into forms which are assimilable by the animal are relatively small. In the case of the corn fodder, we observe better results with lower consumption of dry matter and energy than in the native hay—the two fodders producing the same results—while still larger quantities of both dry matter and energy were appropriated with the sorghum and saltbush, resulting in a loss instead of a gain. There was evidently more energy available for the production of flesh in the case of the corn fodder than in the two latter cases, though the total energy used up was less.

§229. We cannot present so full an account of the heat or energy relations of these fodders. We have determined the general values for all of the fodders, but have studied only three of them in detail. The amount of heat appropriated by the sheep from the respective fodders was as follows, given in small calories: Alfalfa, 30,955,663; sorghum, 25,088,621; saltbush, 23,149,533; native hay, 22,255,418; corn fodder, 19,424,180; timothy hay, 17,406,363 calories. We see that the energy appropriated by the animals does not stand in the order of the gain or loss. Alfalfa produced the greatest gain, and sorghum the greatest loss, with the saltbush very close to it. The native hay and corn fodder each produced a moderate gain, while the timothy produced a slight loss. As the urine was not collected, it could not be examined, and we do not know how much of the energy appropriated was voided in this form.

§230. The amounts of dry matter digested in the experiments with these several fodders were as follows: Alfalfa, 7,734 grams; saltbush, 7,351 grams; sorghum, 6,725 grams; native hay, 5,392 grams; corn fodder, 4,940 grams; timothy hay, 4,501 grams. We see that the order is the same as in the case of the heat or energy appropriated. The greatest gain, that made on alfalfa, agrees with the greatest amount of heat appropriated and the largest amount of dry matter digested, but the next two fodders on which gains were shown are not the next in the order of the energy appropriated or the dry matter digested, but form the fourth and fifth in this order, the timothy standing only about 2,000,000 calories below the corn fodder. The lot receiving the sorghum and appropriating 25,088,621 calories, showed a loss of 8½ pounds, and the one receiving the saltbush and appropriating 23,149,533 calories showed a loss of 8½ pounds, while that receiving timothy and appropriating 17,406,363 calories lost but one pound, and that receiving corn fodder and appropriating 19,424,180 calories gained 3½ pounds.

§231. It would seem then that it is not merely a question of the amount of energy that disappears or is appropriated, that produces the beneficial effects of a fodder, but that these may depend upon other factors, for instance, the amount of energy used up in the process of digestion. We have in the case of the corn fodder favorable results with smaller quantities of material than with any other fodder. We have 4,940 grams of dry matter digested which contained 178.46 grams of proteids, 1,734 grams of carbohydrates as sugars and pentosans, 1,211 grams as cellulose, and 1,817 of extractive matter, not more specifically classified, and from this the animal appropriated 19,424,180 heat units and showed a gain of three and one-half pounds of flesh. On the other hand, we find that the lot fed on the saltbush digested 7,351 grams of dry matter containing 1,090 grams of proteids, 1,280 grams of carbohydrates as sugars and pentosans, 2,064 grams of cellulose, and 2,917 grams of extractives which we have not endeavored to more nearly classify, and from this the animals appropriated 23,149,533 calories, losing at the same time eight and one-half pounds. It is just that I should repeat that, while each of the three sheep lost, one of them lost but one-half pound, but the aggregate for the lot was 8½ pounds.

§232. The heat values of the various extracts of the alfalfa, corn fodder and saltbush were determined, and we found that, as a source of energy, the portion that I have designated cellulose is one of the most important.

§233. I have designated it cellulose to distinguish it from crude fibre, because the portion usually designated as crude fibre was treated in a moist condition with chlorin and then washed and boiled with one per cent. sodic hydrate and subsequently with sulfurous acid. This treatment with chlorin, etc., removed a considerable portion of the energy, but this energy is of little value in any of the fodders, the greatest value being observed in the case of the alfalfa, in which 24.0 per cent. of this energy was appropriated, but in the saltbush and corn fodder it was of no value. The total amount of energy removed from the crude fibre of the saltbush by this treatment was 8,508,528 calories out of a total of 59,205,051 for the hay, and from that of the alfalfa 6,045,840 calories out of a total of 49,585,495 calories fed. The relative quantity of heat removed from the crude fibre of the corn fodder by the chlorin is much less, *i. e.*, 1,482,734 calories out of a total of a little over 25 millions consumed and was wholly non-available. The alcoholic extract is again shown to be the most important portion of the fodder. The heat appropriated from this portion of the alfalfa was 10.7 millions calories out of a total of 30.9 millions; from that of the corn fod-

der, 7 millions out of a total of 19.4 millions, and from that of the saltbush, 5.8 millions out of a total of 23.2 millions.

§234. The second portion in importance was not the same in the three fodders, it being the sodic hydrate extract in the alfalfa and saltbush and the cellulose in the corn fodder. In the alfalfa 8.2 millions calories and in the saltbush 5.5 millions calories were appropriated from the sodic hydrate extracts, but this extract of the corn fodder furnished only 2.1 millions calories. The third protein in importance in the alfalfa and saltbush was the cellulose, which furnished 5.95 millions and 4.4 millions calories, respectively, in these cases. The fourth one in order of value is, in the alfalfa and saltbush, the hydric chlorid extract, from which the sheep appropriated 3 millions and 4 millions calories, respectively. The extracts of the alfalfa have, in the order given, furnished the larger amounts of heat, both absolutely and relatively, but this is reversed in the hydric chlorid extract, that of the saltbush furnishing the larger quantity. The order of extracts of the corn fodder in regard to their heat value is a different one, the alcoholic extract standing first, the residue or cellulose standing second, the hydric chlorid extract standing third, and the sodic hydrate extract falling to the fourth place. In the alfalfa and saltbush, we have a large amount of proteids, but we have seen that these are very freely dissolved by the alcohol and are represented almost as largley by the alcoholic extract as by that of the sodic hydrate, as the following amounts digested in the two extracts will show:

Alfalfa	Alcoholic extract, 486 grams;	sodic hydrate, 698 grams
Saltbush	Alcoholic extract, 553 grams;	sodic hydrate, 378 grams
Corn Fodder	Alcoholic extract, 141 grams;	sodic hydrate, 000 grams
Timothy Hay	Alcoholic extract, 129 grams;	sodic hydrate, 131 grams
Native Hay	Alcoholic extract, 117 grams;	sodic hydrate, 194 grams

from which I infer that it is not probable that the value of the sodic hydrate extract in the alfalfa and saltbush is dependent upon the proteid content of the hays, but due to other compounds. In passing this subject, it may be noted that the proteids soluble in alcohol have as high or higher coefficients of digestion than those soluble in the sodic hydrate. The proteids soluble in hydric chlorid are less in amount and have lower coefficients of digestion than those soluble in alcohol or sodic hydrate.

§235. There appear now good reasons why the native and timothy hays might have repaid us for making a comparative study of them, even though the timothy has already been studied in this sense, at least to some extent, and the native hay could give results of a general value only.

§236. The native hay and corn fodder are apparently much more similar than any other two of the six; they gave the same

feeding results and both effected it at a comparatively small cost of energy. This is particularly the case with the corn fodder, which produced a gain of 3½ pounds in the weight of the sheep receiving it on the minimum weight of dry matter digested and a minimum of energy, 4,940 grams of dry matter, 19.4 millions of calories, and a gain of 3½ pounds. Alfalfa produced a greater gain, but the sheep digested 7,734 grams of dry matter, appropriated 30.9 millions of calories and gained 9 pounds. The effect of poor fodders are best shown by comparison with these, as sorghum, for instance, the sheep digested 6,725 grams of dry matter, 25 millions calories, and lost 8½ pounds; as saltbush, they digested 7,351 grams of dry matter, 23.1 millions calories and lost 8½ pounds.

§237. The methoxyl group is present in all of these fodders, but it is not abundant and is digested to only a small extent, as indicated by our results, and whether it plays any part in determining the value of the fodder or not, is not apparent.

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Bulletin 125 July 1907

The Agricultural Experiment Station

—OF THE—

Colorado Agricultural College

COLORADO FODDERS

A STUDY OF COMPARATIVE VALUES
BASED ON BULLETIN 124

—BY —

W. P. HEADDEN.

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1907

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

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A STUDY OF RELATIVE VALUES OF COLORADO FODDERS

A Continuation of Studies in Bulletins 39 and 93.

By W. P. Headden.

§ 1. The scientific feeder and student of animal nutrition has, for the past forty-five or fifty years, been accustomed to divide fodders into certain big groups to which different names have been applied and now the veriest tyro can talk very glibly of proteids and carbohydrates, but, after all, the practical man, and even our scientific friends, do not adhere tenaciously to the data indicated by the results of the calculations based on the analytical data, but adopt the plainer and easier way of judging the value of a fodder by the effect it produces. A grass may have, according to the results obtained by the analyst, an admirable composition, but if animals will not eat it, its good composition goes for nothing, or if they eat it and constantly lose in weight, the excellent analytic results are of no value. Facts similar to these are met with, sometimes in this extreme form, sometimes in a milder form.

§ 2. Hays made from different plants vary in quality, i. e., in their fitness to be used as fodders and in their fattening qualities. These differences are very great even when no individual idiosyncrasies of the animals fed can be appealed to to explain away the facts. In a bulletin published by the Colorado Experiment Station we have made an attempt to explain the reasons for these differences. It appears from this work that the extract obtained by boiling the fodder repeatedly with 80 per cent alcohol, is the most important part of the fodder; it contains a large, if not the largest, part of the nitrogenous substances and very large quantities of other matters.

§ 3. It is pointed out that water alone will extract as much as 40 per cent of alfalfa hay, This hay is easily damaged by rain. The explanation offered is the ready solubility of so large a portion of the hay.

§ 4. The alcoholic extract is itself highly digestible. This is true, too, of the nitrogenous matters contained in it. It is further demonstrated that this alcoholic extract furnishes more energy to the animal than any other portion of the fodder. This is true in each of the six fodders whose composition is presented.

§ 5. It is shown that the fodders yield extracts to muriatic acid, also to a solution of caustic soda, which vary in value in the different fodders. In some fodders, the former extract, but in others the latter, has the greater value. In alfalfa, the portion removed by the caustic soda, but in the Colorado native hay that removed by the muriatic acid is the more valuable portion. To the most of us, however, the surprising feature is the high value possessed by what is designated as residue or cellulose, the portion left after treating the hay with alcohol, muriatic acid, caustic soda and chlorin. It would seem that there would be but little or nothing remaining of a hay after being treated with these chemicals in the succession given, still

it is shown that one half or more of this residue is digested by sheep in the case of alfalfa hay, native hay and corn fodder, but less than one-half in the case of timothy hay and sorghum fodder, and even less than one-third in the case of one of our native saltbushes which was studied with the purpose of seeing whether it might be used as a fodder. This residue or cellulose is not only digested by the animals to a large extent, over one-half of it being digested in the fodders which gave good feeding results, but the energy which it yielded to the animal was large, in the corn fodder, the alcoholic extract alone furnished more energy.

§ 6. We have heard so much about proteids and their value that we have come to think of these substances as the most important portions of a fodder. This is largely because they are not as abundant as some other kinds of substance and may be present in a fodder in such small quantities that the feeder may have to purchase them in order to obtain results which he desires. This bulletin does not in any way lower the value to be placed on the nitrogenous portions of the fodder, but it shows that the value of a fodder depends largely upon the character of its other constituents. The writer shows that two lots of sheep, one receiving alfalfa hay, the other salt bush hay, were digesting very large and nearly the same amounts of porteids but very different amounts of other substances included under the general term of carbohydrates, particularly was this true of the cellulose which represents those carbohydrates which were capable of resisting the action of the several chemicals previously named. The sheep receiving alfalfa gained nine pounds in live weight during the five days elapsing between he two weighings, and those receiving saltbush hay lost eight and one-half pounds. Attention is called to this fact and in explanation, it is pointed out that the cause of loss in the latter case is not due to a lack of proteids, for the amount of this class of substances digested is nearly as large as in the former case. The question in regard to the relative value of the nitrogenous constituents of the fodders is suggested and while it is admitted that there may be a difference in this respect they are assumed to be equal, no data being at hand to justify any assertion to the contrary.

§ 7. The two lots of sheep digested approximately the same amounts of proteids and it is held that assuming them to have the same value in the two fodders, the explanation of gain in the one case and the loss in the other is not to be found in this part of the fodder and consequently we have to study the effects of the other constituents.

§ 8. The amount of the different extracts, their digestibility and their fuel values are taken as indicators of their respective values. It is acknowledged that a small amount of some therapeutically active substance might exert a very markedly disturbing action, but though this fact was known and looked for no indication is given that such effects were noticed. In fact, the statement is repeatedly made that the animals appeared comfortable and contented, that they chewed their cuds contentedly or equivalent expressions. This assumption re-

garding the relative value of the proteids in the two fodders, which, by the way, have high coefficients of digestion, 72.99 in the alfalfa, and 66.2 in the saltbush, and the probable absence of any deleterious substances having been made, there is left as the next important group, the substances represented by the nitrogen-free extract, which is divided into several parts, each of which, however, contains some proteids, except possibly the chlorin extract and the cellulose or residue.

§ 9. The alcoholic extract represents these nitrogen-free substances in a large measure, but contains at the same time a large portion of the nitrogenous matter of the plant; the extract obtained by exhausting the hays with cold water and hot water with subsequent addition of malt extract are, taken together, of some moment, as they represent in round numbers one-tenth of the air-dried hay and usually show from fair to good coefficients of digestion; it is also true that the portion removed by treating the portion remaining after boiling with one per cent caustic soda, with chlorin, again heating with caustic soda and subsequently with a solution of sulfurous acid, may amount to a noticeable quantity, but its coefficient of digestion is always low, often zero. So that the carbohydrates are practically divided into four parts, those soluble in alcohol, those soluble in muriatic acid, those soluble in caustic soda and those which are insoluble. The value of this class of substance has always been recognized but in this work it is emphasized, particularly in the comparison of these two fodders, the alfalfa hay and saltbush hay. In the former they are not only abundant in the alcoholic extract but they are also highly digestible; but this is not true of the other three important parts of the saltbush hay, i. e., the parts soluble in muriatic acid, caustic soda and that which is insoluble in any of the solvents used; these parts of alfalfa hay have high coefficients of digestion and the sheep gained in weight, but in the case of the saltbush hay they have low coefficients of digestion and the sheep lost in weight.

§ 10. The great difference between these two fodders, alfalfa, an excellent one, and saltbush, a very poor one, lies in the character of the carbohydrates present in the two plants. While the proteids may be different, they are abundant in both plants and are both highly digestible. In this respect these two fodders are much more nearly alike than any other two fodders studied. This is fortunate for in regard to the quantity of proteids present and their digestibility, the hays are similar but the carbohydrates in three of the important portions of the plants are very unlike, though abundant in both plants. They are very difficultly digestible in the saltbush and required so much energy to effect their digestion that there was not enough appropriated from the fodder to do the work and carry on the animal functions without using some of that already stored in the body, therefore the animals lost flesh.

§ 11. The large amount of proteids digested in each instance and their high coefficients of digestion are tacitly assumed to be presumptive evidence that they yielded more energy to the animals than

was necessary to do the work of fitting them for assimilation by the system. Their similarity in quantity and coefficients of digestibility is considered fortunate as practically eliminating the question of their influence, the difference of the effects of these food elements not being great enough to materially change the effects of the other elements in consideration.

§ 12. The carbohydrates are not divided into classes except to the extent and in the manner explained in the following: The familiar members of this class, glucose and cane sugar, do not occur in large quantities in ordinary hays, but they are wholly digestible and where present constitute a valuable factor in the fodder. The saltbush contains more of these two sugars taken together than the alfalfa does, so if we consider the value of the saltbush as depending on the quantity of these two substances alone it should be better than the alfalfa, but this is not the case. The same is true in regard to two others of these carbohydrates, the gums and starch which are more abundant in the saltbush than in the alfalfa. The frame work and tissues of the plants themselves very largely belong to this class of substances, carbohydrates, and though we do not know the definite composition of some of these plant constituents, they can be changed, in part at least, so as to yield compounds whose composition is known and the yield of such compounds by the different hays when treated with different agents has been made use of to establish the differences in the fodders themselves. The sugars already named are only two well-known members of this class of substances which include a number of others not so commonly known to the general public. Some of these related substances yield one and some another sugar under the action of certain agents. By taking advantage of these properties, the following differences between the alfalfa and the saltbush have been established.

§ 13. It should be kept in mind that the object had in view in doing this work, was not primarily to establish the value of the fodders but to find out, if possible, why one gives goods results and the other poor ones. There is a kind of sugar to which the name wood-sugar has been given because it is formed when wood is subjected to a certain treatment. The sugar or the material from which it can be made, is capable of being determined with approximate accuracy by methods which have been worked out. In this way, it is shown that certain carbohydrates are present in that portion of the alfalfa soluble in alcohol which are wholly absent from the saltbush and these substances in the alfalfa are easily digestible. A similar carbohydrate is present in the muriatic acid extract of the alfalfa. There is, however, twice as much of this substance in the corresponding extract of the saltbush, but that found in the alfalfa is wholly digestible, while that in the saltbush is wholly indigestible; this may simply mean that but little of this portion of the hay is changed while passing through the alimentary tract and fecal matter capable of yielding this substance is present in the dung in such large quantities that there is more in the feces than was taken

into the animal as food. But here is a big difference, one which appears to be too great to be explained away by unavoidable errors in the work. The individual extracts in the different fodders were examined in this way and also the residues or the cellulose that resulted from the treatment adopted. In this connection, it is shown, the carbohydrates yielding this substance taken as a common measure, that these residues or celluloses are very different in their values. The caustic soda does not, it is true, dissolve very much of this class of substances, but the alfalfa yields about one-third as much as the saltbush, of which but a small part was digested, while that dissolved out of the saltbush is not only nearly three times as great but a very much larger proportion of it serves as food. The most striking difference in the character of these carbohydrates is presented by the residues obtained which ought to be approximately pure cellulose and consequently have nearly the same value. This, however, is not at all the case, for this portion of the alfalfa has almost three times the value of that of the saltbush if the coefficient of digestion is a proper guide in judging of their value. A little later we will find that this fact is shown by another method, establishing with a considerable degree of certainty, that there is a very great difference in the character of this portion of the respective fodders.

§ 14. The muriatic acid extract of the alfalfa contains, as previously stated, less of the substance corresponding to the wood sugar than the saltbush, but the alfalfa yields a sugar that may also be obtained from milk sugar and which is not present in the saltbush, or if present at all, constitutes a very small portion of the fodder. This sugar is apparently very digestible. The coefficient obtained for all the sugar found in the muriatic acid extract which included both kinds of sugar mentioned is high. There is but little of the material corresponding to the wood sugar present in this portion of the alfalfa, but there is some. The alfalfa and the saltbush belong to entirely different orders of plants, and the pea family, to which the alfalfa belongs, yields this sugar which may be derived from the sugar of milk, while the saltbush and ordinary hays yield but little of this, yielding wood sugar in its stead.

§ 15. The energy relations, i. e., the amount of heat gotten out of the fodder by the animals and also out of the different parts or extracts of the fodders were determined and the fodders were found to be very different in this respect, as well as in those respects already pointed out. Furthermore, it was shown that the same amounts of energy appropriated from different fodders produce different results, measured by the loss or gain in the live weight of the animal, or we may say that the efficiency of the energy varies in different fodders.

§ 16. As we have, in the main, taken alfalfa and the saltbush for our purpose so far, we will continue to use them though we will have to take up the grasses later.

§ 17. We have previously related that it was found that the extract obtained by treating the fodders with alcohol appeared to be

the most important portion in all cases, though they showed a great difference in value in the cases of the different fodders. In these, the alfalfa and the saltbush, the amounts of alcoholic extract digested by the lots of sheep in five days chance to be the same, but the energy appropriated by the lot which received alfalfa was very much greater, nearly twice as great as that appropriated by the lot that received saltbush. It will be recalled that it was stated that there was so big a difference in the character of the carbohydrates of these two plants that it could not in any way be ascribed to errors of manipulation. We here find, by another method, that the alcoholic extract of the saltbush yielded only a little more than one-half of the energy that the corresponding alfalfa extract yielded. This difference might be due to the different quantities of proteids in the two extracts, but it is not, provided that they have even approximately the same value in the two fodders, for they received and digested a larger quantity of proteids in the form of saltbush hay than they did as alfalfa hay, showing that, viewed from the standpoint of fuel value, the difference very probably lies in the character of the carbohydrates. While it is admitted that little is known of the character of the proteids dissolved out of these or any other fodders by alcohol, we have as good a guide for our judgment in this case as we have in others pertaining to the character of fodders, i. e., the animals digested not only a larger quantity of nitrogenous matter when fed on saltbush but assimilated a larger proportion of that that they received. We will not consider all of the extracts in this manner lest too many similar statements should obscure rather than emphasize the facts intended to be brought out, so we will only consider the muriatic acid extract and the residue or cellulose. The former, muriatic acid extract, furnished very much more digestible dry matter in the case of the saltbush than in that of the alfalfa, one third more, but its coefficient of digestibility was materially lower, two-thirds that of the alfalfa, and we find the energy almost exactly one-half of the amount yielded in the case of alfalfa. The proteids in this extract of these two fodders were nearly the same, both in regard to their quantity and digesibility, showing again that the difference was probably due to the character of the carbohydrates. The only other and last big feature of these two fodders that we will mention will be the cellulose which, owing to the method of preparation, contains very little nitrogen, no ready formed sugars or subsances soluble in alcohol, water, muriatic acid, caustic sodic or removable by chlorin, in other words, the soluble substances and those portions of the woody tissue capable of being broken up and removed by these agents had already been eliminated and though this residue would appear to be of but little value as food for the animal, we find it always one of the first three portions in importance. We would probably, without definite knoweldge to the contrary, not only consider this portion of but little value, but would expect to find it of nearly equal value in all cases, which is no nearer the truth than the former. In these two cases, we find that over one-half of the alfalfa cellulose is digestible while less than three-tenths of the saltbush

cellulose can be digested by sheep, and further, while the sheep received a much larger amount of energy in the form of saltbush cellulose than in that of the alfalfa cellulose, they were able to utilize only two-thirds as much energy, again showing that it is the character of the carbohydrates, peculiar, perhaps, to each individual tribe of plants which determines its feeding value.

§ 18. We have now rapidly examined these fodders in their main features, the most interesting of which is the relation of the energy values. There may be many errors in our work and serious mistakes of judgment, but all of these can not obscure the fact that a smaller amount of energy consumed as alfalfa produced a bigger result than a larger one consumed in the form of saltbush. In order to make this clearer to the casual reader, I will state this result a little more fully. The sheep consumed forty-nine million units of energy as alfalfa hay and gained nine pounds; the same sheep under as favorable conditions as could be produced, consumed fifty-nine million units of energy as Saltbush and lost eight and one-half, a total difference of seventeen and one-half pounds of flesh. The repeated observation that the carbohydrates of the saltbush, whether in the form of cellulose or the other forms making up the whole structure of the hay, are more difficulty digestible than those of the alfalfa may be interpreted as indicating that the work necessary to prepare the carbohydrates for assimilation is so great that it cannot be accomplished by the digestive processes in the sheep, when the saltbush is the only fodder fed, except by using up energy stored in the body in the form of flesh, muscle or fat. The amount of energy supplied was more than abundant to have produced excellent results, had the sheep been able to set it free without the expenditure of too much energy previously stored in the form of flesh. In the case given, there were actually ten million more units of energy in the fodder consumed as saltbush than in that consumed as alfalfa, but the energy which the sheep appropriated from the saltbush was, in round numbers, eight millions less than that appropriated from the alfalfa.

§ 19. The amount of energy appropriated by the sheep with which this experiment was conducted was a little over twenty-three millions units, a quantity somewhat in excess of the amount appropriated from two other fodders on which each lot of sheep made a gain of three and one-half pounds. This indicates that the absolute amount of energy appropriated in the case of the saltbush was considerably more than would have sufficed to maintain the animals in the condition in which they were at the beginnig of the experiment, but the fact is that they each lost. The question in regard to the cause of this loss is answered above in that we suggest that not only this energy was used up, but as much more as corresponds to eight and one-half pounds of flesh, in converting these carbohydrates into proper food for the animals, in warming the excessive amount of water which this fodder caused the sheep to drink, and in maintaining the animal functions.

§ 20. We have so far presented the study of the two fodders, alfalfa and saltbush, only incidental mention having been made of the

other fodders studied, one of which was studied as fully as the two already mentioned, namely corn fodder. This fodder is one easily digested in the sense in which we have indicated that the saltbush is difficulty digestible. By this I mean that comparatively small amounts of heat are used in the work of preparing this fodder for assimilation. In this case, we have a little less than nineteen and a half million units of energy appropriated and each sheep gained, the lot making an aggregate gain of three and a half pounds. This is the smallest amount of heat on which an actual gain was made. This shows the relative efficiency of the energy in the corn fodder, as compared with saltbush. This relative efficiency of the corn fodder would appear to be much greater if compared to that of sorghum in which form the animals appropriated twenty-five million units of energy and lost 8½ pounds. The fuel or energy values of the various extracts of sorghum were not determined but the coefficients of digestion, especially for the two large and important divisions represented by the muriatic acid extract and the residue, cellulose, indicate a low digestibility of the carbohydrates. The proteids probably do not influence these results in any material way. The results obtained with sorghum, it having been fed alone, were surprisingly unfavorable. The large amount of heat used and the low coefficients of digestion found for the greater portion of the fodder indicates that it, like the saltbush, requires more work to bring it to an assimilable form than is an equivalent to the energy yielded by the fodder. In the case of sorghum, the alcoholic extract is abundant and has a high coefficient of digestion, due, very probably, to the fact that it is rich in the two sugars, glucose and cane sugar. I did not determine the fuel values of this or any other of the extracts made of the sorghum. The fuel value of the fodder itself is almost exactly the same as that of the saltbush, which is low, thirty-eight hundred units of energy against forty-two hundred in the corn fodder, the actual difference being three hundred and fifty units for each gram of dry hay.

§ 21. The three important portions of corn fodder are, the portion dissolved by eighty per cent. alcohol, the cellulose and the portion soluble in muriatic acid. These extracts, the alcohol and muriatic acid extracts, both have very high fuel values and are easily digestible. The residue or cellulose has a rather low fuel value but owing to its coefficient of digestion being high, it furnishes more energy than any other portion of the fodder, the alcoholic extract excepted.

§ 22. The deportment of the proteids in this fodder is very different from those of alfalfa. The greater portion of them being found in the caustic soda extract in the latter case, while the greater portion is found in the alcohol extract of the corn fodder. The cellulose of the saltbush proved to be much less efficient in furnishing energy to the animal than that of alfalfa, but in comparing the efficiency of the cellulose of corn fodder and alfalfa we find that that of corn fodder is the more efficient. The animals did not eat the stalk with the pith cellulose if they could avoid it, so the cellulose in this case does not include much of the pith cellulose, though it does include some.

§ 23. The amount of proteids in the corn fodder is comparatively small and their coefficient of digestion low, so that, whatever their distribution and importance, their influence cannot materially alter the general results obtained. The corn fodder cellulose is instructive because it has a rather lower fuel value than the other celluloses, but it has the highest coefficient of digestion of any of them.

§ 24. We have now presented a hay made from a member of the pea family, one of the goosefoot family and one from a very coarse grass, corn. We will next consider a mixture of small grasses, our native hay, and pure timothy.

§ 25. The native hay is a mixture of grasses and sedges with some rushes. We find this hay quite similar in composition to the corn fodder but a smaller proportion of the digestible proteids is taken into solution by alcohol than in the corn fodder. The combined amount of glucose and cane sugar is less, the wood is greater and the amount of still another sugar to which I have not specifically referred, but which is found in the caustic soda solution, is large enough to be considered separately. Such are the striking features of similarity in the composition of the two. The fuel values of the native hay were not studied in detail but the general results were that twenty-two and a quarter million units of energy appropriated as native hay proved to be exactly equivalent to nineteen and a half million units appropriated as corn fodder, if the gain in live weight is a correct standard by which to measure their effects.

§ 26. The native hay contains more proteids than the corn fodder but not as large a quantity as alfalfa hay, and they have a high coefficient of digestion. The carbohydrates are easily digestible but less so than those of either the alfalfa or corn fodder, and we find that it takes some three million units more of energy in the form of native hay than in the form of corn fodder to produce the same result, which is in perfect keeping with the lower coefficient of digestibility of the carbohydrates of the native hay.

§ 27. The timothy hay was studied to the same extent and in the same manner as the native hay. We find in it the same characteristics that we found in the native hay; a moderate amount of proteids, but their coefficient of digestion is somewhat lower. The nitrogenous constituents are soluble in eighty per cent alcohol to the extent of about one-third of the total amount present and this portion has a high coefficient of digestion.

§ 28. It seems to be generally true that the nitrogenous matters soluble in alcohol are readily digestible, for instance, we find that of this portion of alfalfa, eight-tenths is digestible; of the timothy hay, eight-tenths; of the saltbush, nearly nine-tenths; of the native hay, six-tenths, and of the corn fodder, six-tenths. I have stated that the alcoholic extract of a hay stands before any other portion in feeding value, as indicated by its amount, general coefficient of digestion and fuel value. The statement seems to hold to a large extent in regard to the proteids. No distinction being made between the amids and the proteids.

§ 29. We find that the fuel value of the timothy hay is quite high, about forty-four hundred heat units for each gram of dry matter but the sheep can only utilize this energy to an extent of a little less than one-half, and as a result we find that timothy hay does not furnish enough energy to make a good fodder. The lot of sheep receiving the timothy appropriated nearly seventeen and a half million units of energy and showed a slight loss in flesh.

§ 30. I have in this work refrained from analyzing the extracts further and have permitted some indefiniteness in the statement of the results, but I consider these points of no material importance to our present purpose. For instance, I have made no effort to determine whether the wood sugar, xylose, is made up wholly of this sugar, or is mixed with another closely related one. I have also considered it a matter of small importance in this study whether the reducing power found in the caustic soda extract is really due to wood-sugar or to one more nearly related to cane sugar. The fact has been established that in some hays, at least, the wood sugar is a mixture of two sugars and that the sugar present in the caustic soda solution probably does not belong to the group of wood sugars at all. These questions pertaining to the nearer chemical composition of the hays are interesting and important but for the purpose of this bulletin, I have deemed them omissible. The difference in the sugars from the alfalfa and other fodders has been mentioned, but this sugar, galactose, appears to be present in some of the other fodders, too, to a smaller extent.

§ 31. We find the difference between these fodders so marked, especially, in regard to the readiness with which they appear to yield their energy to the animals and the work which is necessary to prepare the food constituents for assimilation, that it does not appear strange that the fodders acually have very different feeding values.

Bulletin 126 January 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

CANTALOUPE BREEDING

BY

P. K. BLINN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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*After March, 1908

CANTALOUPE BREEDING

PHILO K. BLINN

The cantaloupe industry has made its principal development since the introduction of the Netted Gem variety; for due to its small uniform size and good carrying quality the growth of the industry has been possible.

It was not until the excellent quality of the cantaloupes produced on irrigated land under dry climatic conditions was realized, that the industry became prominent.

The first cantaloupes on the eastern markets from the arid region were shipped from Rocky Ford, Colorado, in 1896. Their superior flavor was an innovation to the eastern melon trade; the contrast in quality was so striking as compared to the eastern and southern products that the Rocky Fords at once became regarded as a new variety, and under that popular symbol have won a national reputation. Each year thousands of cars of cantaloupes are marketed as genuine Rocky Fords, but from widely distant fields; those from the southern states appearing on the markets early in May, and continuing the supply from various states until late in October.

The phenomenal growth of the industry and the great demand, has established the cantaloupe as one of the favorite fruits of the American table; if the quality could always be assured there is hardly a fruit that could rival it in popularity or price.

Some of the causes that lead to poor quality are: Unfavorable climatic conditions, plant diseases, insect injuries, glutted markets and the unavoidable delays in transportation; many of which are beyond any apparent means of control. Yet when we consider what has been accomplished by plant breeding in other lines, it does not seem impossible that there could be developed a disease-resistant cantaloupe that would possess such superior qualities as to enable it to endure adverse conditions and still reach the markets in better state and with higher flavor than any we now possess. To this end cantaloupe breeding becomes an important feature of the industry, for at best the crop is a hazardous one, due to the above named influences and until recently careful seed selection has been generally neglected.

A GOOD DEMAND FOR GOOD SEED.

The general growth of the industry has created a large demand for cantaloupe seed, and naturally Rocky Ford has been an important source of supply. It seems that it is more than the notoriety of the name that gives an intrinsic value to the seed produced

at this point, for the cantaloupe growers of California and the southern states look to Rocky Ford each year for their supply of seed. They unanimously concede that they can mature their melons a week to ten days earlier and be assured of more uniform results in regard to size and quality, when they plant the Colorado grown seed, than if they use the same strain after it has been grown native with them a year or so. It is a good instance of the change in plants, that environments may sometimes produce, and how these variations may be transmitted to a degree, when the plants are grown under other conditions. The effects of altitude and latitude have long been regarded as an influence that hastens maturity in plants when their seed are grown in lower or southern regions. It is also a notable fact that grains produced in the dry climatic conditions of Colorado are heavier per bushel and are superior in quality to that grown in humid sections where the rainfall is excessive; it is evident, that where the moisture is controlled, and the soil and weather conditions will develop the fine flavor and qualities found in the Rocky Ford cantaloupe, that the same conditions will, in a measure, lend an influence to mature the seed with superior germinating power, vigor of growth and strong inherent tendencies, over that produced in less favored localities. This would indicate that points in Colorado are destined to continue as superior cantaloupe seed growing centers, provided the growers will resort to the proper methods of seed breeding that will insure the improvement of the cantaloupe in all its possibilities.

INDEFINITE AND UNSYSTEMATIC SELECTION.

Those familiar with the subject realize that a large amount of the seed that has been saved in the past was not choice selected seed, for much of it is saved from cantaloupes that were unmarketable for some reason, or it was saved late in the season from immature melons after frost has destroyed the vines; improvement under such conditions would hardly be expected and deterioration would be almost inevitable. However, there are growers who have been interested in producing choice cantaloupe seed, but even at best their system of selection has been too indefinite and incomplete to insure the best results. The plan of most growers in selecting seed for their own planting, is to lay aside the choicest specimens from the piles as they are gathered for market; these may be further graded before they are finally saved for seed, which would seem that the system possessed some merit, yet it is quite analogous to the use of the fanning mill for developing improved grain, or the selection of seed corn from the crib to better the corn crop; the selection is incomplete, for the seed selected from an indiscriminate pile does not take into consideration the many inherent tendencies of the plant from which it was produced, no matter how

perfect the specimens may chance to be; another serious weakness is the lack of adherence to a definite outline of the qualities that should be embodied in a perfect cantaloupe.

The different ideals of selection have given rise to numerous strains of the Rocky Ford cantaloupes, which are simply the Netted Gem variety developed under different conceptions of type and quality; there may be the element of cross-fertilization in the origin of some of the strains yet the foundation stock of all was originally the same strain, and the general characteristics of this variety has constituted the principal lines that have been considered in the selection of the Rocky Ford seed. For example, the uniformity of size and the netting are points that have been considered and are well developed in several strains; yet equally essential are the inherent traits of the plant and the quality of the fruit. For example, early, prolific production and disease resistance are of prime consideration as well as a thick, fine flesh of rich flavor with no disagreeable consistency or after tastes which are all qualities that should be embodied in a perfect cantaloupe.

Doubtless the acme of perfection may never be realized, for some of the points may be antagonistic attributes, and the laws of plant breeding are not so well defined as to enable one to outline a scheme for seed selection that will insure the desired results in a given time.

AN EXPERIMENT TO IMPROVE CANTALOUPES.

The object of this article is with a view of outlining the methods and results of a definite investigation along this line, presenting the facts that have grown out of this work in such a way as to serve the future efforts in cantaloupe breeding.

The Colorado Experiment Station, in 1903, instituted an investigation to develop if possible, a cantaloupe that would be immune to the attacks of the fungus disease, commonly known as "melon rust" or "blight," which is a serious menace to the melon industry. The first effort was a study of the cantaloupe fields to ascertain if any resistant tendency existed in the various strains of the Rocky Ford cantaloupes.

Owing to the different soil and the cultural conditions of the different farms, it was impossible to draw conclusions, as all fields were affected to some extent and eventually all succumb to the disease.

It was evident that a comparative test under more uniform conditions would be necessary to determine the point in question. Accordingly the following season the principal strains of the Rocky Ford cantaloupes were tested in comparison on a piece of ground that had been seriously affected with the fungus. The plat was uniform in condition and had the same care in all respects, yet the

results of the test revealed that one of the strains had marked disease resistant qualities, for when the balance of the plat was practically dead and dried up with the disease the rows of this variety had a number of plants only slightly affected.

The seed of these resistant individuals were secured and the following season, 1905, the same plat of ground was again used, in order that the rust-resistant feature could be developed in as adverse conditions as possible. It chanced this season that one of the rows in the plat was planted with the seed of one cantaloupe and the product of this row was so uniform in all of its qualities that it was evident that individual selection was an essential point to consider; also the increased percent of the resistant plants gave evidence that the quality was transmitted and could be developed by seed selection.

The seed of the most resistant plants were again saved, but this time each one was kept separate, the next year, 1906, the same plat was again used. The test demonstrated that the product of some plants reproduced quite uniformly and in others there was a tendency to vary; this seemed to emphasize the importance of selecting individual melons as well as the plant, and isolating the breeding plats as far as possible to prevent undesirable crosses. One row in the plat was planted as a check row, with the seed of a very choice melon but which had not been selected for the disease-resistant quality. This row was destroyed with the rust at least two weeks before the balance of the plat gave signs of the disease to any extent. (Plate I)

As the disease began to develop in the plat, a careful study was made and the most resistant plants were numbered by a stake, and as the melons ripened the most desirable were selected and the seed saved separate with a descriptive record made of each. Near the close of the season the plat was gone over again and noted as to which plants had been the most resistant during the summer; this revealed the fact that a few had been more enduring than all the rest. The seed of these could be easily identified and those that scored the highest in points of quality, were selected for the work in 1907. The seed were planted in separate adjacent blocks of fifty hills each on the same old plat that now, for five consecutive years had been devoted to cantaloupes, which is enough to insure a failure on account of the disease with any of the ordinary strains of seed after it has been grown on the same soil so long; but since the beginning of the resistant selection the plat has shown a decrease in the presence of the disease, while in adjacent fields the fungus has been as prevalent as ever and even more destructive. Except for a few individual plants, the plat during the past season has been practically free from the disease.

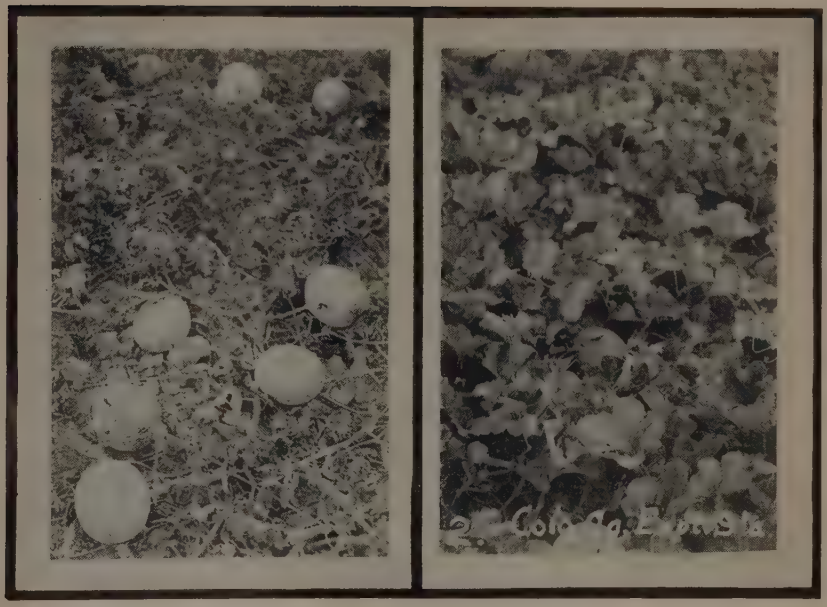

PLATE I.

1. A VINE RUSTED ON CHECK ROW
2. ADJACENT VINE SHOWING RESISTANCE TO RUST

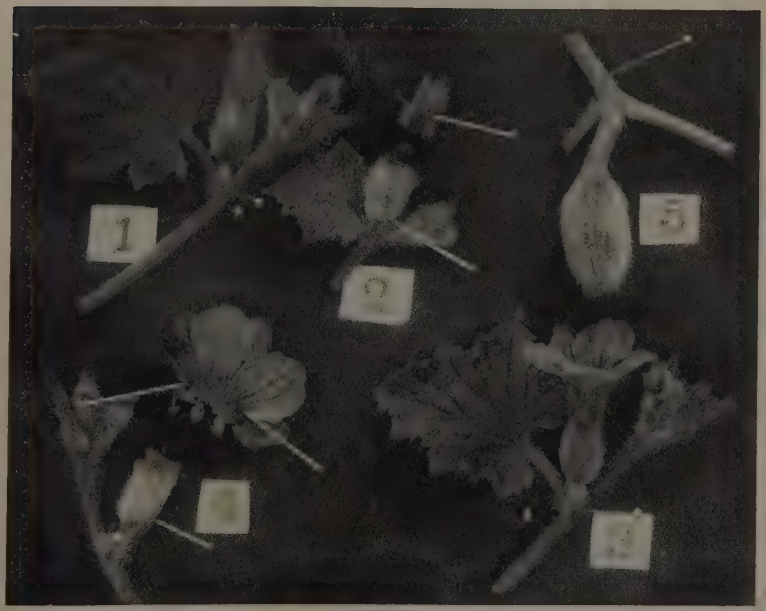

PLATE II.

1. BUD 24 HOURS BEFORE OPENING

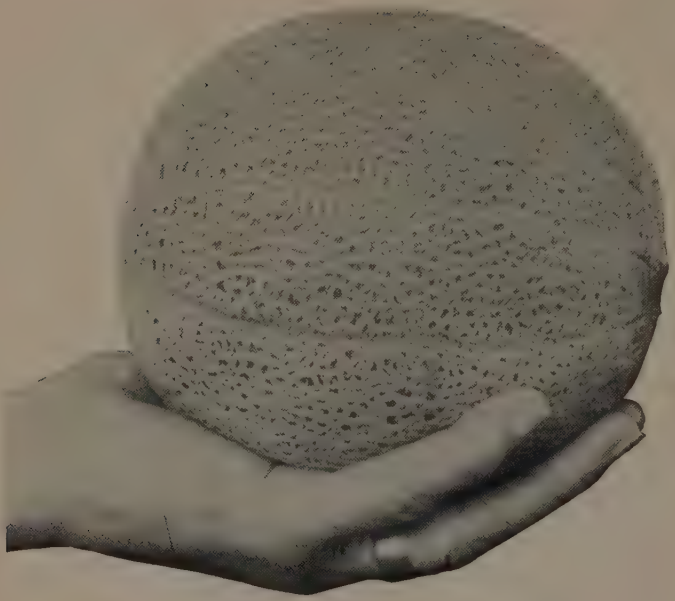

PLATE III.
EXTERNAL POINT OF NETTING AND SIZE

PLATE IV

PRACTICAL TESTS OF THE RESISTANT STRAIN.

Several tests of the rust-resistant strain were made with commercial growers in the vicinity of Rocky Ford, and all the reports have been of a flattering nature. Similar tests were also made in Illinois and Indiana through the co-operation of the Experiment Stations in those states, and the following copies of letters are the reports sent in.

From C. G. Woodbury, Assistant Horticulturist of the Agricultural Experiment Station, Purdue University, Lafayette, Indiana, under date of August 30, 1907:

"You remember that you forwarded me some seed early last spring, of your new strain of the rust-resistant Rocky Ford melon. I placed this out in several localities in Southern Indiana, where the rust is usually prevalent, and am very pleased to report that your strain has proven to be nearly immune; in one place where there was a small patch directly across the road from a field which the rust ruined entirely, the vines from your seed showed no effects of the disease whatever. To test the matter as severely as possible I had badly affected runners from the field that was dying of the rust cut off and scattered among the plants of the rust-resistant strain; even then they became affected only slightly.

"No doubt before this you have had a visit with Professor Orton of the Department of Agriculture, and he is able to corroborate my statements, since I had the pleasure of visiting some of the fields with him in Southern Indiana a short time ago."

From John W. Lloyd, of the University of Illinois Agricultural Experiment Station, Urbana, Ill., October 2, 1907:

"The melon seed you so kindly sent me last spring exceeded my highest expectations in reference to rust-resistance under Illinois conditions. I distributed the seed among a number of the commercial growers located at different points. Many growers lost or failed to plant the seed or did not secure a stand, but with all who succeeded in growing a crop the results were the same: The vines remained green and vigorous after other melons were dead from the rust; the melons netted exceedingly well and were fine flavored. The only objection raised against the melon was its late maturity; in some cases the entire crop from other varieties had been marketed before any ripe specimens of the rust-resistant could be found. It is true that the maturity of the other varieties was hastened by the rust.

"I believe this melon will be exceptionally valuable for extending the season after other varities are gone. However, in our experimental plat where the other varieties were protected by spraying and the rust-resistant plants left unsprayed, there was not so much difference in the time of ripening, though the rust-resistant were somewhat later. Toward the end of the season the **unsprayed** rust-resistant vines were in better condition than the sprayed vines of the other variety.

"The small lot of exceptionally select seed which you sent was planted by itself at a distance from other melons, and the plants thinned to one in a hill. There was considerable difference in the rust-resistance of different plants, and I have saved seed from some of the most resistant with a view of planting each separately, and making further selection next year."

The results of the investigation have demonstrated the possibility of controlling, to some extent at least, the injuries from the "rust" fungus by systematic seed selection and breeding.

VARIATIONS OF INDIVIDUAL SELECTIONS.

The seed of eighty choice individual cantaloupes of the rust-resistant strain were planted, on alfalfa sod, in blocks of twenty-five hills each, under as uniform conditions as possible. The object of this test was to determine the efficiency of the disease resistance on soil less affected with the fungus, and to study the problems of individual variation from individual selections, with a view of improving other characters in the Rocky Ford cantaloupe.

The test did not reveal any greater disease resistance by virtue of the alfalfa sod, but a marked contrast in the degree of resistance was revealed in the plats of different individual selections.

The variations of some of the plats made it easy to distinguish their outlines after the vines had run together and completely covered the ground in the field. The seed was all of the same variety and had been carefully selected for several years, and was considered a pure strain.

Had the seed been jumbled together and planted as usual, the contrast and variations of the different selections would not have appeared to attract attention, but by planting each separately it was evident that it makes a vast difference in results which one was chosen for seed, even from a number of seemingly choice specimens.

The first contrast noted was the variation in the germination of the plats, which ranged from forty to one hundred percent and was clearly the result of vitality in the selections, the date of first setting fruit varied eight to ten days in different plats without apparent reason, and the time of ripening of some of the plats was prolonged to nearly three weeks, though this difference may have been partly due to the premature ripening of some of the plats most affected with the fungus, and as the most rust resistant selections were usually the latest maturing plats, yet it was clear from the early setting and development of the plats before the disease was manifest, that some of the plats were much earlier than others. There were also various combinations of the different qualities in the different plats; for instance, the rust-resistant feature was associated with excellent melons in regard to netting, form and size, in some plats, while in others the qualities were inferior in this respect.

When the pedigrees were traced a general uniformity prevailed in the plats whose seed had a common parentage a year or two previous, yet irregularities were constantly appearing in the products of some of the selections, and also the tendency to breed true seemed equally characteristic of others. In one instance the color of the flesh and the solidly filled seed cavity was uniformly reproduced for four succeeding years.

The variations of the individual selections seemed to come from no other reason than the inherent tendency of the individual, for the whole plat had the same care in every respect possible.

The recent application of Mendel's laws of heredity offers an explanation of the results observed in this experiment. The heterozygous unit factors of some of the selections produced the irregular variations, while the homozygous, or pure unit factors of others, resulted in characters breeding true.

HYBRIDIZATION.

So far in the investigation we have employed only seed selection to secure the desired results; but now the need of hybridization is manifest to combine the desired qualities found in different selections, for simple seed selection has been inadequate to this object. To combine the rust-resistance with earlier maturity is much desired, and to this end observations and tests have been made during the past season to ascertain the fact and methods necessary for artificial cross-fertilization of the cantaloupe flowers. As a result several cross-pollenizations were made between some of the best selections of the rust-resistant strain and an abnormal early setting plant of another strain known as the "Watters." According to Mendels law of constant proportitions resulting from such hybrids, we may confidently expect the desired combination if the qualities are compatible.

It was found by observations that the flower of the Rocky Ford cantaloupe is quite the exception to most of the cucurbitaceous plants like the cucumber and many other varieties of melons, which have their stamens and pistils borne in separate flowers, while the Rocky Ford variety is hermaphroditic, that is the stamens and pistil are produced in one flower. It also has purely staminate flowers produced in great profusion at the intersection of nearly every branch.

It is evident that cross-fertilization is readily possible, yet the arrangement of the flower and the results of observation would indicate that self-pollenization is quite as common or more so.

The numerical arrangement of the flower was found to vary, the three-lobed pistil with three stamens was the common form, but four and even five were encountered. The result of a three-lobed pistil is shown in No. 1 in Plate IV.

METHODS OF ARTIFICIAL FERTILIZATION.

The pollen of the cantaloupe flower has been found to ripen about the time the flower is opened and the pollen is usually shed at this time, which is usually early in the morning; to fertilize the flower and have the results of known origin, it is necessary to find the bud about twenty-four hours before it opens (Plate II,

No. I), which can easily be told by observation; in this stage it should be emasculated, before the pollen lobes are ripe. By cutting around the base of the corolla and calyx, the two may be removed with the stamens attached, leaving the pistil free and exposed. (Plate II, No. II and IV.) A small paper sack is then tied over the stem to protect the pistil from foriegn pollen until the following morning, when the stigma will be at about the same stage, as if the flower had not been disturbed, and ready to receive the pollen.

The desired pollen is introduced from a fresh opened flower, by pulling off the corolla the stamens are exposed, showing the ripe pollen grains which are transfered by touching the ripe pollen lobes to the pistil or stigma until it is well covered with the yellow pollen grains. The paper sack is then replaced for several days until development begins.

SUMMARY.

The general conclusion of the investigation is that systematic seed breeding will intensify any desired qualities found in cantaloupes, as well as in corn and other crops.

The essential points for breeding cantaloupes are:

1. Keeping records that will establish the history of a plant at any time.
2. Close observation to detect desirable variations.
3. Individual selections.
4. Comparative testing to determine relative merits.
5. Judging the average results of a selection rather than the behavior of an individual in it.
6. An understanding of physiological botany, in order to perform successfully cross-pollenization when necessary.

The principal points, or unit characters to consider, might be enumerated as follows:

1. Germinating vitality. 2. Vigor of growth. 3. Early setting. 4. Quick maturity. 5. Prolific yields. 6. Uniformity of the desired qualities in the product.

The standard for the Rocky Ford Cantaloupe of today might be given to include the following qualities:

1. Proper size to pack in the standard crate.
2. Fine, heavy, light grey netting, covering the entire melon. Plate 3.
3. Color character of the background or interstices between the netting, such as will indicate to the eye, by a slight change of tint, when the cantaloupe is ready to pick, which is rather an olive green, and one that does not turn yellow fast.
4. A thick flesh and solid filled seed cavity. (Plate 4, No. 2.)
5. A firm, smooth texture, fine grained and free from any fiber or water-core.
6. A green colored flesh is usually preferred, though commonly it is combined with orange or salmon tint.
7. The flavor is the ultimate test; it should be rich, sweet and spicy, free from any disagreeable consistency or after tastes.

If the same care and attention was paid to the breeding and growing of improved cantaloupes, or other crops, there would be a great demand for pedigreed seed, as well as the call for registered horses, sheep or cattle.

Bulletin 127 January, 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

CLIMATE OF COLORADO

TEMPERATURE

21 Years' Record at Fort Collins

BY

L. G. CARPENTER

and

R. E. TRIMBLE

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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*After March, 1908

TEMPERATURE AT FORT COLLINS

21 YEARS' RECORD

Graphical Diagrams of the Normal Daily Temperature and the Highest and Lowest Daily Average

By L. G. CARPENTER *and* R. E. TRIMBLE

The Meteorological records for Fort Collins have been continued under essentially the same system for 20 years. Observations were made tri-daily up to July 1, 1889, when we changed to the twice daily records.

The average temperature which forms the basis of these charts is the mean of the maximum and minimum temperatures of the day. The observations have been made by several different persons, but since 1891 have been made by Mr. R. E. Trimble.

The instrument house has been under substantially the same conditions, but moved several times for short distances. It has been of the Standard Weather Bureau type, a louvre-sided instrument house, with the floor about 6 feet above a grassy plot.

The dotted line of the diagrams shows the average temperature for every calendar day during the year. It is the average of 20 years, 1887-1906 inclusive.

The highest daily average during the 20 years is indicated by the upper line, and the lowest daily average by the lower line. Thus the warmest first of January in the 20 years averaged 39°, and the coldest -4°. The diagrams do not show the minimum temperature nor the maximum. The average range for January is 28°, and for August 33°. The range on the days of extreme temperature is much greater, often 40° or even 55°, so that if one selects the portion of day to be outside, the physiological effect is that of much more moderate extremes. This is still more the case when the extreme dryness of the climate is considered, moderating the physiological effect.

During the 20 years here recorded the maximum has been as follows.

MAXIMUM

91°	1 year
93°	3 years
94°	3 years
95°	5 years
96°	2 years
97°	4 years
99°	2 years
99.6°	1 year

The minimum for the year has been as follows, below zero:

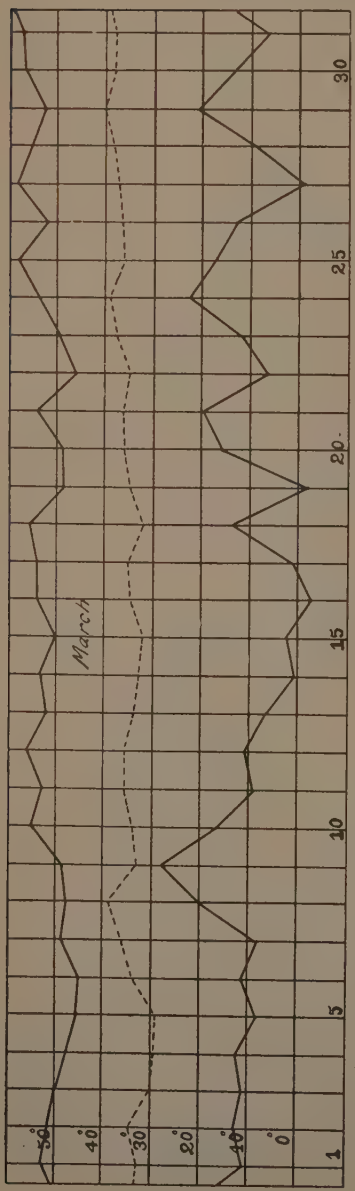
— 5°	1 year
6°—10°	2 years
11°—10°	2 years
16°—20°	4 years
21°—25°	4 years
26°—30°	6 years
31°—35°	2 years
—38.4°	1 year

From the above record it is an even probability that the temperature will exceed or fall short of 94.6° for its maximum and -23° for its minimum. The average temperature is 45.7°, with a probable error of 0.2°; or it is an even probability from present information that after a much longer series of observations, the average will be found to be between 45.5° and 45.9.°

There is also given in Table I the monthly averages of temperature as found throughout the twenty years; in Table II, the table of extremes for each month; in Table III, the average daily range for each month.

January
50°
40°
30°
20°
10°
0°
-10°
1
5
10
15
20
25
30

February
50°
40°
30°
20°
10°
0°
-10°
1
5
10
15
20
25
30


March
50°
40°
30°
20°
10°
0°
1
5
10
15
20
25
30

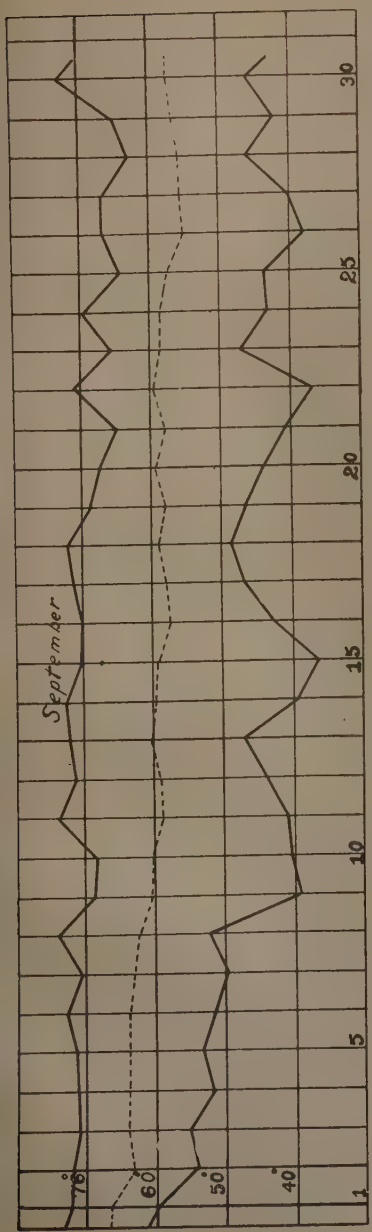
April
60°
50°
40°
30°
1
5
10
15
20
25
30

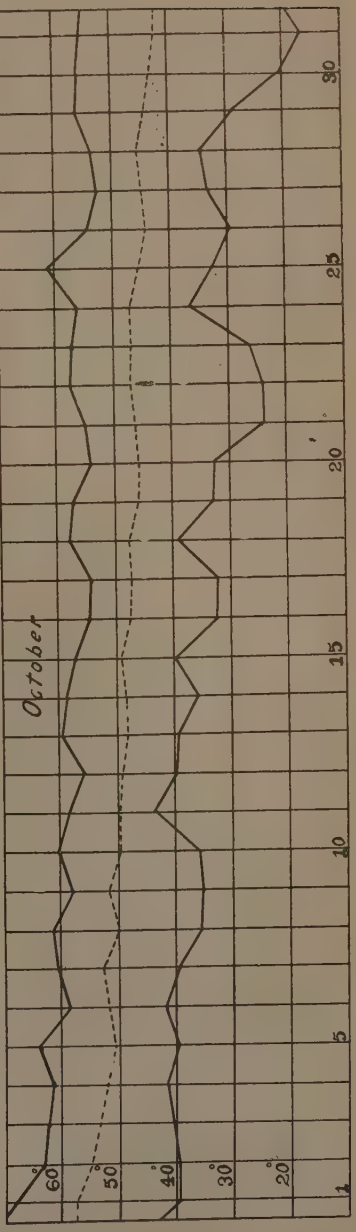
May
70°
60°
50°
40°
1
5
10
15
20
25
30

June
70°
60°
50°
40°
1
5
10
15
20
25
30

July
80°
70°
60°
50°
1
5
10
15
20
25
30

August
80°
70°
60°
50°
1
5
10
15
20
25
30


September
70°
60°
50°
40°
1
5
10
15
20
25
30


October
60°
50°
40°
30°
20°
1
5
10
15
20
25
30

November
50°
40°
30°
20°
10°
0°
1
5
10
15
20
25
30

December
50°
40°
30°
20°
10°
0°
-10°
1
5
10
15
20
25
30

TABLE I.

AVERAGE MONTHLY TEMPERATURE

At Agricultural College, Fort Collins, Colo., in Degrees Fahrenheit

YEAR	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1887.....	25.7	23.7	39.8	45.2	57.7	68.1	68.4	65.6	60.4	46.0	38.2	29.7	47.1
1888.....	22.2	37.1	37.4	55.3	54.4	68.1	72.8	66.6	61.4	49.2	33.0	31.3	49.0
1889.....	22.2	25.6	41.6	50.6	54.1	63.5	68.1	66.6	53.9	44.1	27.0	32.1	45.8
1890.....	24.7	30.0	38.0	46.5	58.0	64.0	71.1	66 1	58.3	47.4	38.1	37.8	49 1
1891.....	22.2	19.8	30.5	46.6	54.8	60.9	66.9	66.3	61.1	48.7	35.1	28.7	45.1
1892.....	21.1	27.8	33.7	44.0	50.0	61.7	68.2	67.3	62.4	47.7	37.4	23.1	45.4
1893.....	32.6	26.9	35.2	42.7	52.3	65.3	70.7	66.8	60.0	48.7	33.6	33.6	47.3
1894.....	23.9	18.7	37.4	48.3	57.2	63.2	69 1	68.3	58.9	51.3	40.5	25.6	46.9
1895.....	23.9	21.1	34.2	49.2	53.6	59.2	65.3	67.6	61.0	46.9	33.7	28.6	45.4
1896.....	32.6	33.4	34.0	46.6	57.0	65.3	70.2	69.0	58.8	48.0	30.8	34.0	48.3
1897.....	24.8	27.6	32.3	45.8	51.8	63.1	66.8	66 8	63.7	48 5	35.6	25.4	46.6
1898.....	25.6	34.1	32.7	47.7	51.6	64.0	69.0	69.9	58.6	46.3	30.3	23.6	46.1
1899.....	24.7	9.9	29.7	44.7	53.8	63.6	67.0	67.6	61.4	46.1	40.8	27.7	44.7
1900.....	30.9	24.2	39.1	42.9	57.8	67.1	67.9	68.0	58.6	50.2	37.4	31.6	48.0
1901.....	28.2	23.9	34.7	44.0	57.0	63.3	72.5	69.0	59.0	49.7	40.0	27.7	47.4
1902.....	24.2	32.0	35.3	45.7	56.1	63.6	66.0	68.7	56.8	48.8	36.1	27.1	46.7
1903.....	30.3	14.0	30.6	45.3	52.2	59.3	68.5	68 1	56.8	49 6	36.1	32.3	45.3
1904.....	26.1	35.3	39.6	46.2	53.7	59.9	65.6	67.0	59.2	48.9	39.7	31.9	47.8
1905.....	25.2	21.4	42.2	43.4	52.1	64.8	65.7	68.2	60.5	43.6	37.8	27 0	46.0
1906.....	30.9	30.5	25.0	47.1	55.0	61.8	64.9	67.2	58.7	46.3	33.6	34.8	46.2
1907.....	25.9	35 4	43.3	42.5	48.9	60.9	67.8	66.9	58.7	49.9	32.9	30.5	47.0
Average...	26.1	26.3	35.5	46.2	54.7	63.4	68.2	67.5	59.4	47.9	35.6	29.7	46.7

*Fort Collins, Colo., Agricultural College. Latitude, 40° 34′. Elevation, 4,993 Feet. Located on the Plains, 4 miles east of the foothills of the Rocky Mountains.

TABLE II.

EXTREME MONTHLY TEMPERATURES

At Agricultural College, Fort Collins, Colo.

YEAR	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1887.....	58.	**—19.0**	70.	— 8.	80.	8.	83.	16.	90.	24.	96.	45.
1888.....	71.	**—28.**	68.	14.	79.	3.	91.	30.	84.	30.	97.	42.
1889.....	58.	— 3.5	62.	—16.0	67.8	**—17.0**	79.	24.	81.	31.0	90.5	35.
1890.....	65.6	—13.0	68.3	**—20.0**	70.1	— 9.0	78.0	13.8	85.0	29.1	92.2	32.7
1891.....	48.9	**—16.3**	46.5	—1.50	66.0	— 4.1	81.9	12.9	84.6	31.2	86.9	37.9
1892.....	61.2	**— 28.4**	55.1	— 9.0	70.1	—19.7	78.7	19.4	82.0	31.4	86.5	35.4
1893.....	67.3	— 2.2	66.7	—10.0	78.3	— 1.9	78.9	7.6	88.7	23.1	**95.0**	31.3
1894.....	63.3	—22.0	54 6	—15.3	73.0	9.9	79.0	16.4	85.9	27.1	91.0	37.9
1895.....	57.2	— 9.6	62.2	**—27.8**	80.2	—18.0	78.7	17.0	90.0	28.6	88.7	33.0
1896.....	67.8	— 7.6	68.1	3.9	75.8	— 6.8	80.0	7.0	88.3	31.0	91.2	39.3
1897.....	64.0	**—26.0**	59.5	— 5.3	65.3	— 7.0	77.2	20.0	82.3	31.6	90.1	35.3
1898.....	61.5	—11.8	63.7	6.7	66.3	— 6.2	86.2	14.5	81.8	29.6	**97.2**	36.0
1899.....	55.0	—16.8	50.8	**—38.4**	65.7	-24.5	78.0	8.0	82.5	23.4	**96.1**	36.4
1900.....	63.0	— 6.0	56.0	**—23.4**	76.9	9.7	73.9	5.1	84.7	29.8	**94.4**	40.7
1901.....	61.8	- 21.7	63.0	—14.7	71.9	- 7.5	81.8	8.7	82.9	31.1	94.4	38.2
1902.....	62.2	**—31.4**	63.0	—23.0	63.9	2.0	79.8	18.0	85.9	29.6	96.0	37.0
1903.....	61.3	1.0	46.0	**—28.0**	66.2	—10.0	78.2	12.8	85.1	27.4	92.5	37.0
1904.....	65.0	**— 7.0**	69.0	3.0	70.0	10.0	79.8	14.1	82.0	28.2	87.2	38.4
1905.....	63.5	— 22.3	66.2	**—26.8**	70.3	12.4	78.0	12.0	76.3	29.5	92.3	40.0
1906.....	67.8	— 3.5	67.0	— 5.0	69.9	**-24.6**	80.1	22.1	82.9	33.0	89.9	37.2
1907.....	62.6	— 4.7	68.8	— 2.8	80.3	2.8	80.0	5.7	83.0	19.2	87.7	33.9
Extreme	71.	—31.4	70.0	—38.4	80.3	—24.6	91.	5.1	90.0	19.2	97.2	31.3

TABLE II. (CONT'D.)

EXTREME MONTHLY TEMPERATURES

At Agricultural College, Fort Collins, Colo.

YEAR	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1887.....	**97.**	50.	97.	44.	91	32	88.	11.	78.	13.	61.	0.
1888.....	**99**	51	98	44	89	32	75	20.	64.	16.	68.	4.
1889.....	**97**	37 5	97	41 3	93	23 0	85 2	24 9	61.	1.0	66 5	3 0
1890.....	93 4	46 9	**95 3**	39 5	85 3	28 0	77 0	15 7	75 7	6 5	62 9	5 8
1891.....	89 4	41 2	**93 1**	36 7	88 8	34 3	79 8	19 5	75 9	— 6 2	60 0	10 0
1892.....	92 7	45 3	**99 2**	33 9	89 3	27 5	87 0	18 7	62 7	10 6	65 6	17 4
1893.....	94 9	44 2	91 7	38 3	90 0	25 7	82 0	11 8	70 7	**—12 8**	60 4	2 5
1894.....	**94 4**	46 0	92 2	39 5	88 6	39 9	80 7	19 3	78 0	1 1	64 7	**—24 0**
1895.....	93 2	44 9	93 7	42 3	**95 0**	23 2	79 7	14 8	73 7	2 9	66 7	— 5 0
1896.....	**95 8**	48 8	93 8	40 2	90 0	31 8	84 2	21 0	74 7	**11 3**	66 1	0 5
1897.....	**94 8**	38 9	93 5	42 7	89 8	33 8	81 7	21 5	75 6	— 3 0	63 0	—10 8
1898.....	97 0	44 3	95 6	43 1	90 2	29 7	85 7	16 2	71 3	11 3	55 0	**22 3**
1899.....	94 0	44 6	95 2	39 7	94 6	29 0	86 7	23 7	69 5	15 0	63 7	— 9 3
1900.....	92 9	40 2	94 0	41 2	88 2	29 7	83 0	12 5	74 0	8 7	62 9	— 22 0
1901.....	**96 7**	47 9	96 7	43 6	86 6	29 4	82 0	25 0	69 6	12 0	64 6	**—31 0**
1902.....	98 0	38 8	**99 6**	42 3	89 8	22 0	80 0	25 5	69 2	3 8	58 2	—17 6
1903.....	**95 0**	36 0	94 6	41 9	92 5	26 0	81 0	20 0	71 0	—10 0	61 0	5 0
1904.....	90 7	40 3	**91 0**	33 0	90 0	29 6	80 1	17 8	75 4	0 5	65 7	1 0
1905.....	91 0	42 3	**93 2**	44 8	90 5	30 8	85 3	8 0	74 0	3 4	62 2	— 4 0
1906.....	**92 6**	41 0	92 0	39 2	86 9	37 3	83 2	19 4	70 2	— 9 3	64 5	7 0
1907.....	**94 4**	44 6	91 6	45 0	85 6	31 0	81 8	22 4	70 0	- 1 2	61 7	— 5 4
Extreme	99	36 0	99 6	33 0	95 0	22 0	88.	8 0	78 0	—13 0	68 0	—31 0

NOTE.—Extreme temperatures of each year indicated by blackfaced type.

TABLE III.

DAILY AVERAGE MONTHLY RANGE OF TEMPERATURE

At Agricultural College, Fort Collins, Colo.

YEAR	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1887.....	23 2	31 5	35.3	28.6	32.6	33.1	29.7	31.7	32.8	33.6	30.8	27.6	30.9
1888.....	32 7	28.	31.3	32.7	24.5	28.6	32.6	29.8	35.9	28.0	28.9	31.1	29.9
1889.....	28 2	27 2	28.8	27.5	25.2	29.6	33.1	34 2	34.9	28.7	25.4	28.6	29.3
1890.....	30 2	30 0	29 7	26 9	30.2	34.4	31.9	29.7	37.4	32.7	33.6	31.3	31.5
1891.....	26 4	24 1	21 5	29.5	27.5	26.9	30.1	32.7	33.8	36.8	26.8	25.2	28.4
1892.....	28.0	22.8	23.7	29.2	22.2	30 4	30.6	37.7	40.6	32 3	29.0	27.5	29.5
1893.....	33.6	29.2	30.1	28.7	29 0	36.1	34.6	32.6	37.4	34.0	32.2	27.2	32.1
1894.....	31 0	30.0	29 9	32 5	28 8	32.2	32 6	33.4	34.8	34.3	34.5	29.5	32.0
1895.....	26 1	28.2	28.7	34 1	29.4	28.7	27 8	32.5	38.2	34.1	29.4	29.3	30.6
1896.....	32 9	31.5	24.5	32.3	31.5	31.4	29.2	32 2	28.0	33.2	28.5	30.1	30.2
1897.....	30.9	26 7	25 0	27.5	30.2	28.9	32.9	30 9	32.6	32.6	30.8	27.2	30.1
1898.....	30 1	33.0	30 4	33.6	22.3	31.7	32.1	35 4	39.4	29.6	28.4	28.6	31.2
1899.....	28.6	30.7	23.6	31 6	31.6	32.5	28.6	33 1	37.9	28.3	31.8	29.9	30.7
1900.....	31 4	27 1	29 6	23.3	29 2	33.8	31.6	37.0	30.6	34.8	31.4	31.3	30.9
1901.....	31 2	29.0	26 9	25 8	28.2	30.0	35.2	32.1	32.7	33.7	33.4	25.2	30.3
1902.....	30 0	27 0	25.5	30.6	28 8	30.8	33.0	32 8	34.6	31.3	27.0	25.5	29.7
1903.....	27 8	28 3	24 4	28.2	31 4	24.6	32.7	33.7	34.9	35.3	34.2	33.4	30.7
1904.....	33 3	30.2	30.4	29.7	25.0	27.1	29.7	31.6	33.7	35.0	39.9	32.0	31.5
1905.....	25 4	29.2	25.9	24.0	23.2	29.5	29.3	34.1	37.4	33.5	31.8	36.2	30.0
1906.....	33.0	35 5	23 0	25.7	28.1	39.1	27.9	32.2	28.8	31.6	24.9	26.6	29.7
1907.....	26.9	31 0	32.0	26 9	23.8	31.6	30.8	31.9	33.0	35.4	33.4	29.7	30.5
Average....	29 6	29.1	27.6	29.0	27.7	31.0	31.2	32.9	34.7	32.8	30.5	29.2	30.4

Bulletin 128 April 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

ALFALFA STUDIES

PROGRESS REPORT

BY

P. K. BLINN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

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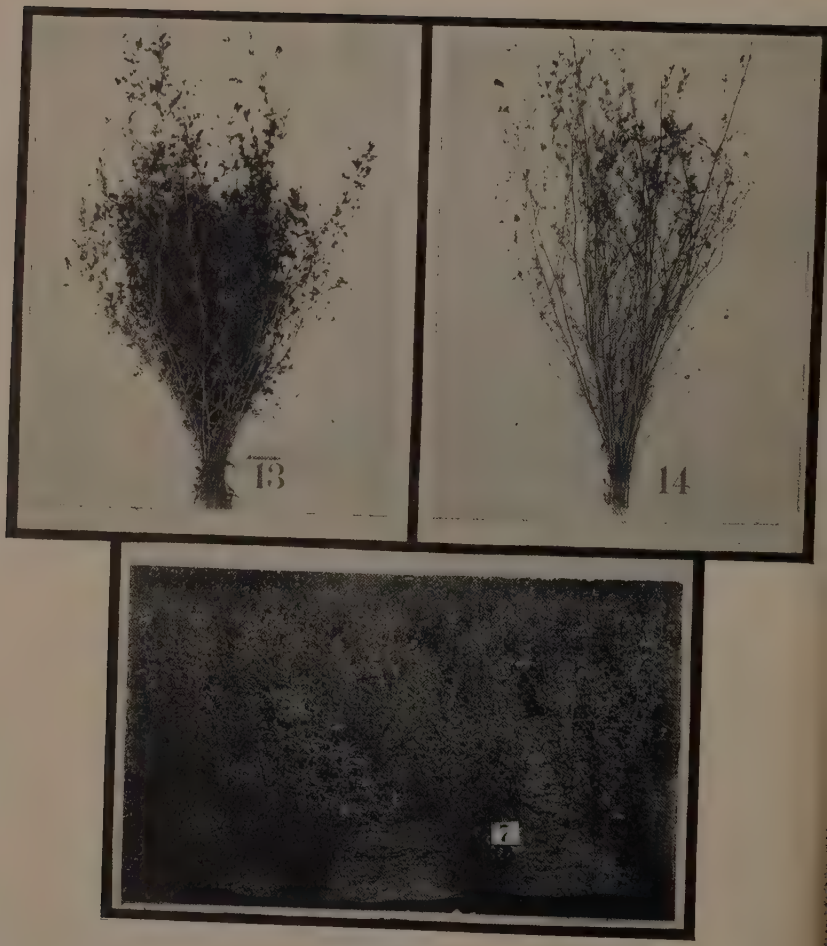

PLATE I.

. 13. A-4, 7-12, yield of seed 5 grams. Desirable hay type.

No. 14. Plant A-5, 7-18, no seed. Leaves dropped by fungus.

No. 7. G-6. Arabian Plat just 4 months old from seed. In bloom.

ALFALFA STUDIES

PROGRESS REPORT

By P. K. BLINN

Alfalfa forms the basis of our farm values throughout the western states; its unique adaptation to the semi-arid conditions makes it an invaluable asset to our agriculture. Owing to its power to survive a drought, or exist on scanty moisture, its deep growing root system enables it to reach a great but a deep-lying supply of soil fertility, that is beyond the reach of common plant roots, but which will in turn, become available to any crop if the proper crop rotation with alfalfa is established.

The power of alfalfa to restore worn out lands, and to build up soil that is deficient in humus and nitrogen, is apparent to the most casual observer, who will compare the crops grown on alfalfa sod, with those on ordinary soil, or even where barnyard manure has been heavily applied. Realizing these facts, it is evident that alfalfa must be grown more extensively in our crop rotations to maintain and restore the soil that is being depleted by the large crops of sugar beets and other products.

Many acres of alfalfa hay land are sacrificed each year, for the more remunerative returns from beets, cantaloupes or potatoes grown on alfalfa sod, and as a result alfalfa hay is becoming scarce, and the price is advancing to a point that will tend to dishearten the stock feeder. Also the high prices realized for hay has not encouraged saving the alfalfa crop for seed, consequently the price of good alfalfa seed is about equal to the cost when it was first introduced. In the estimation of some, the high price of land in the irrigated sections precludes the use of alfalfa as a profitable crop; especially on the small tracts and even on the larger farms, the proper proportion of alfalfa to other crops is seldom maintained and evidently the *real merit* of alfalfa is overlooked.

When expensive land is occupied with alfalfa for recuperation, which sooner or later will become necessary, it is apparent to all that it should be made to yield the highest returns possible, in hay, seed or fertility. To this end the alfalfa seed breeding work has been instituted. The idea was suggested in 1904, when investigating the insect injuries and other causes for the poor yields of alfalfa seed in the lower Arkansas valley in Colorado. It was then noted that there was a great contrast in the seed yields of different plants under apparently the same conditions, and also, that the type and quantity of hay from different individuals varied. Seed from some of the most promising plants were secured and sown the following

season in a comparative test, with common alfalfa and some Turkestan seed from Germany, furnished through Professor W. H. Olin. This test the first season revealed a better seed production in the plants grown from seed selected for heavy yielding traits, but the second season's growth revealed the superior hay producing qualities of the Turkestan plants, which also yielded as high as an ounce of seed from a single plant. The selections that season were principally from the Turkestan plants, descriptions of which were reported in Bulletin 121, Colorado Experiment Station. Through Mr. J. M. Westgate, of the Department of Agriculture, a large list of foreign and native strains of alfalfa seed from different states were secured for a wider base of comparison in the preliminary nursery work of selecting the best strain for the improvement of the qualities desired in alfalfa.

The new alfalfa nursery planted the past season comprises sixty-four different varieties or promising individual selections, each planted at the same time and given the same care and conditions, and could be considered under a fair comparative test. Each plat was designed to contain two hundred individual plants, twenty inches apart each way, and each plat separated by a path forty inches wide.

The plats are designated in the following manner, the first tier of plats on the north are lettered "A" and numbered from east to west, one to eight, the next tier to the south is lettered "B" and the plats in the tier are numbered the same as the first tier, and so on, the eight tiers are lettered to correspond to the first eight letters of the alphabet.

The individual plants in a plat are designated by two numbers, the first denotes the number of the row in the plat, which is numbered from north to south, the second number denotes the plant in the rows, which are also numbered, but from the east to the west.

The nursery was planted April 15, 1907, and thinned to single plants about the middle of July. The following is an epitome of the first season's observations:

Plat A-1—Individual selection No. 1, from Turkestan variety, 183 plants. Irregular in type, undesirable for hay or seed compared to others.

Plat A-2—Individual selection No. 2, from Turkestan variety, 163 plants. Irregular in type, rather subject to fungus diseases.

Plat A-3—Individual selection No. 6, from Turkestan variety, 146 plants. Irregular in type, but fair for hay, no seed formed.

Plat A-4*—Individual selection No. 17 (from single plant on railroad right-of-way, grown without irrigation). Very uniform in type, upright in growth, fine stems and leaves, good hay type and fair set of seed, 165 plants. Very continuous in bloom.

Plat A-5*—Individual selection No. 12, from Turkestan plants, 179 plants. Irregular type, coarse stems, very sprangly growth, leaves shed off badly, no seed.

*See Plates.

PLATE II.

6. Argentine alfalfa. From Plat E-4, -14. Good hay and seed type. 12 rams of seed.

Contrast in size of bloom.

No. 17. Argentine alfalfa. From Plat E-2, 1-19. Good hay and seed type; 13 grams.

Plat A-4, after plants were cut.

PLATE III.

No. 1. Arabian alfalfa, Plat D-2, 9-12. No. 2. D-2, 2-9.

Contrast in individual plants same age.

No. 8. Plat E-6, 9-5. Arabian alfalfa. No. 3. Plat D-3, 2-5. Mexican alfalfa.

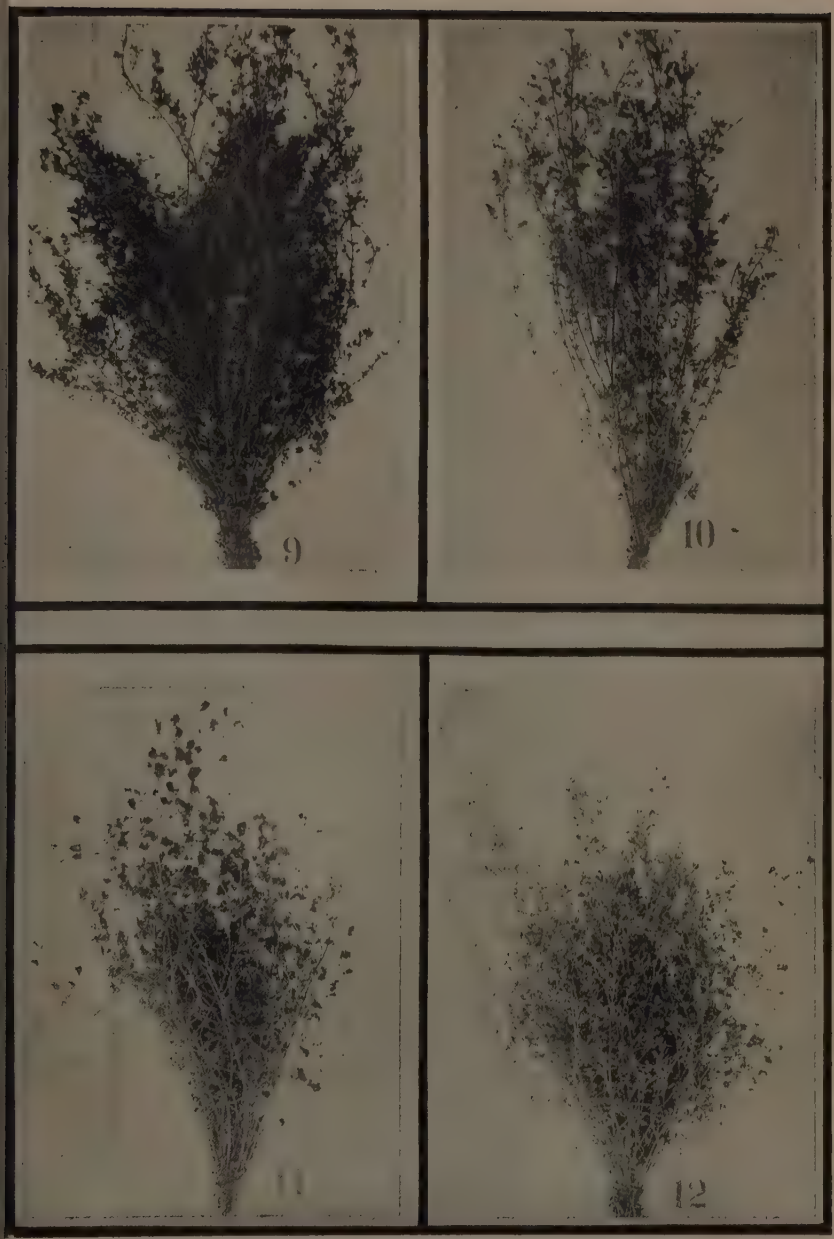

PLATE IV.

No. 9. Argentine. Plat E-4. Plant 7-6. Thickly set to leaves. Yield of seed, 2 grams.

No. 10. Ecuador. Plat E-8. Plant 7-1. Tall, stiff stems, set well to seed. Yield, 7 grams.

No. 11. Utah. Plat D-8. Plant 6-1. Remarkable yield of seed. 24 grams from

No. 12. Ecuador. Plat E-8. Plant 3-4. Fine combination of seed and hay quali-

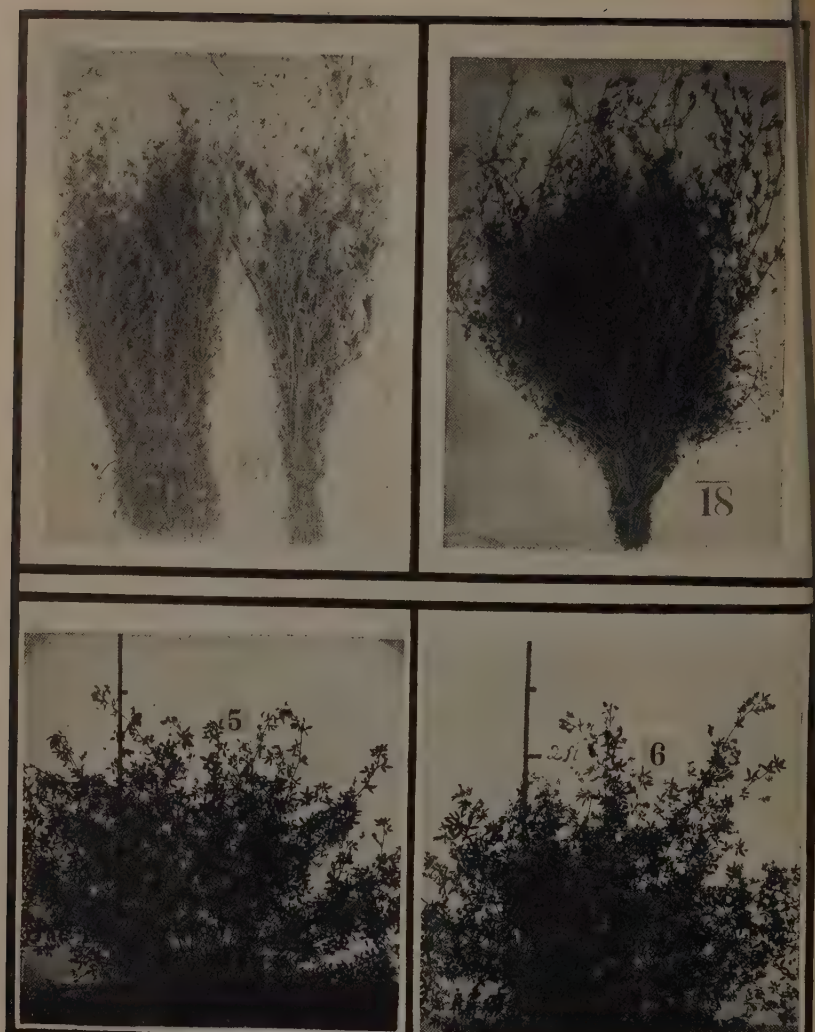

PLATE V.

No. 15, from Plat E-3. Dry land Nebraska. Plant 10-17, to left. Remarkable stooling trait, 250 stems from one single plant the first year. Yield of seed, 7 grams.

No. 18, from Plat D-5, 6-20 Sand Lucerne, Pullman, Wash. Extra fine stems and leaves, fine hay type. Yield of seed, 4 grams.

Contrasting Qualities of Single Plants.

No. 5. From Plat E-4, 10-1. Argentine. This plant grew adjacent to No. 6, and shows that while they are similar in size there is a contrast in seed yield. Yield, 6 grams.

No. 6. From Plat E-4, 9-4. Argentine. This plant, while a fine hay type, is also a good seed yielder; produced 20 grams.

Plat A-6—Individual selection No. 16, from Turkestan variety, 153 plants. Irregular type, sprangly stems, but fair for hay, no seed.

Plat A-7—Individual selection No. 10, from Turkestan variety, 147 plants. Fairly regular in type, but leaves much affected with fungus, no seed, hay qualities fair.

Plat A-8—U. S. Department No. 991, Turkestan, 35 plants. Very poor.

Plat B-1—U. S. Department No. 12231, Texas Turkestan, 74 plants. Very irregular in type, but some good plants, no seed.

Plat B-2—Individual selection No. 3, Turkestan variety, 172 plants. Fairly uniform and hay qualities fair, no seed.

Plat B-3—Individual selection No. 7, Turkestan variety, 183 plants. Quite uniform, tall, coarse stems, no seed, good yield of hay.

Plat B-4—Individual selection No. 15, Turkestan variety, 180 plants. Fairly uniform in type, very dense set of leaves, very promising hay type, but no seed.

Plat B-5—Individual selection No. 9, Turkestan variety, 185 plants. Tall, coarse stems, no seed, hay fair.

Plat B-6—Individual selection No. 13, Turkestan variety, 181 plants. Fairly uniform type, hay good, no seed.

Plat B-7—Individual selection No. 11, Turkestan variety, 151 plants. Poor hay type, few leaved.

Plat B-8—U. S. Department No. 13999, Turkestan from Washington, 72 plants. Poor stand, but good hay type, but no seed.

Plat C-1—U. S. Department No. 12231, Turkestan from Texas, 29 plants. Poor plat.

Plat C-2—Individual selection No. 5, Turkestan, 166 plants. Fair type for hay, but no seed.

Plat C-3—Individual selection No. 8, Turkestan variety, 178 plants. Tall, stiff stems, coarse hay.

Plat C-4—Individual selection No. 14, Turkestan, 166 plants. Short stems, hay fair, no seed.

Plat C-5—U. S. No. 13521, Algeria, 66 plants. Hay fair, leaves free of fungus, no seed.

Plat C-6—U. S. No. 12803, Setif, Algeria, 123 plants. Hay fair, no seed, leaves free of fungus.

Plat C-7—U. S. No. 12846, Kebelli, Tripoli, 97 plants. Poor plat.

Plat C-8—U. S. No. 16401, Dryland, Pullman, Wash., 83 plants. Irregular in type, some good plants for hay and seed.

Plat D-1—U. S. No. 8823, Arabian, 61 plants. Regular type of upright stems, no seed, poor hay qualities.

Plat D-2*—U. S. No. 12992, Arabian, 129 plants. Very irregular, no good.

Plat D-3*—U. S. No. 11651, Pueblo, Mexico, 76 plants. Irregular type, but some good hay types, no seed.

Plat D-4—U. S. No. 14786, Turkestan, 143 plants. Tall, coarse stems, fair for hay, no seed.

Plat D-5*—U. S. No. 16399, Sand Lucerne, Pullman, Wash., 140 plants. Hay type good, seed fair.

Plat D-6—U. S. No. 17698, Northern Montana, 156 plants. Extra good hay type, thick set to leaves, free of fungus, no seed.

Plat D-7—U. S. No. 12847, Tebis, Tripoli, 60 plants. Much like Arabian alfalfa, upright stems, no seed.

Plat D-8*—U. S. No. 18827, Utah, 121 plants. Extra good type for both hay and seed in some plants, rather irregular on whole.

Plat E-1—U. S. No. 11652, Mexico, 98 plants. Irregular type, but some good plants for seed.

*See Plates.

Plat E-2*—U. S. No. 13768, Argentine, 143 plants. Extra good hay and seed type, leaves free from fungus.

Plat E-3*—U. S. No. 19566, Dryland, Nebraska ,169 plants. Good hay type, seed fair.

Plat E-4*—U. S. No. 12549, Argentine, 142 plants. Irregular types, but some extra good for hay and seed.

Plat E-5—U. S. No. 18470, Sand, Lucerne, Germany, 97 plants. Fair type for hay, no seed.

Plat E-6*—U. S. No. 16267, Irrigation Arabian, 106 plants. Regular in type, upright stems, large leaves, but sun scalded, no seed.

Plat E-7—U. S. No. 16317, China, 115 plants. Very sprangly, hay and seed poor.

Plat E-8*—U. S. No. 14972, Ecuador, 170 plants. Wonderful set of seed, hay fair.

Plat F-1—U. S. No. 11502, Siberia, 48 plants. Very poor traits.

Plat F-2—U. S. No. 13564, Peru, 138 plants. Short stems, fine, thick set with leaves, good seed and hay yield, seed not filled well.

Plat F-3—U. S. No. 9453, Turkestan Bokhara, 30 plants. Very poor types.

Plat F-4—U. S. No. 12772, Turkestan, Oregon, 111 plants. Irregular, hay and seed fair on some plants.

Plat F-5—U. S. No. 16403, Turkestan, Washington, 131 plants. Irregular, some good plants for hay and seed, stiff stems.

Plat F-6—U. S. No. 1159, Turkestan, Kuldja, China, 30 plants. Plants flat on the ground, no good.

Plat F-7—U. S. No. 19969, Highmore, South Dakota, 138 plants. Extra good hay and seed types in some plants.

Plat F-8—U. S. No. 19968, Turkestan, Kansas, 96 plants. Tall, coarse stems, no seed.

Plat G-1—U. S. No. 14497, Russia, 146 plants, Turkestan type. Hay and seed type fair.

Plat G-2—U. S. No. 13437, Arizona, 144 plants. Hay and seed qualities good.

Plat G-3—U. S. No. 18751, Turkestan, 154 plants. Coarse, stiff stems, few leaves, no seed.

Plat G-4—U. S. No. 9395, Turkestan, 75 plants. Sprangly, stiff stems, few leaves, no seed.

Plat G-5—U. S. No. 19508, Kansas, 132 plants. Well set with leaves, good hay type, seed fair.

Plat G-6*—U. S. No. 18628, non-irrigated Arabian, 142 plants. Upright stems, sun scalded tops, no seed.

Plat G-7—U. S. No. 13519, Spain, 142 plants, Arabian type. Hay fair, no seed.

Plat G-8—U. S. No. 13436, Canada, Ontario, 114 plants. Sprangly type, hay and seed only fair.

Plat H-1—U. S. No. 13440, Kansas, 132 plants. Thick set to leaves, good hay, seed set fair.

Plat H-2—U. S. No. 13487, Texas, 146 plants. Good hay type, seed on some plants.

Plat H-3—U. S. No. 679, Turkestan, Bokhara, 54 plants. Very poor type.

Plat H-4—U. S. No. 9452, Turkestan, 96 plants. Very tall stems, few leaves, no seed.

Plat H-5—U. S. No. 18591, Turkestan, Montana, 136 plants. Sprankly stems, hay and seed no good.

Plat H-6—U. S. No. 18425, Turkestan, 123 plants. Sprangly type, seed and hay no good.

*See Plates.

Plat H-7—U. S. No. 9450, Turkestan, Trans-Caucasia, 6 plants. Failure.

Plat H-8—U. S. No. 17792, Spain, 139 plants. Upright form like Arabian, hay and seed only fair.

In all our previous tests the Turkestan alfalfa has proven the most desirable in type for hay. It will be noticed from the above report of nursery that one-half of the plats were sown with Turkestan strains, yet the most leafy plants, and those producing the most seed, were not found in the Turkestan varieties. The second season's growth may reveal different records. Of the plats that produced seed, and were of promising type for seed and hay, the following selections were made, besides the individual selections of exceptional qualities:

Plat A-4—Seed from 150 plants, fine, leafy stems, quite uniform seed producing, secured 11 ounces of clean seed.

Plat E-8—From 50 plants, of heavy seed producing quality, secured 18 ounces clean seed.

Plat C-8—From ten choice plants secured 87 grams of clean seed, plants of short, jointed stems, thickly leaved and fairly set to seed.

Plat D-7—Seed of ten plants of the Arabian type, 71 grams.

Plat D-8—Seed of ten plants of the thick, fine leafed type, 70 grams.

Plat F-2—Seed of ten plants of the short, dwarfed stems, 118 grams.

The above six selections were made with a view of sowing increase plats in order to get seed in considerable amount, as these selections seemed so much superior to the common alfalfa. Besides this the following single plant selections were made, for their individual merit.

Bulletin 129. May 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Extraction of Beeswax

BY

F. C. ALFORD

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

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EXTRACTION OF BEESWAX

BY F. C. ALFORD

The increasing interest in apiculture in many sections of the State, and the frequent inquiries relative to the best method of extracting the wax, justify the preparation of this bulletin.

The combs used for the extraction of wax are usually old brood combs. These, of course, contain a large amount of foreign matter which renders the complete extraction of the wax very difficult, and results in forming a residue, known as slumgum.

Some of the methods in vogue at present have been practiced for a long time, others are of comparatively recent origin. Though I have sought for data, definitely established by experiments, regarding the relative efficiency of the different methods, I have been unable to find such, and have therefore attempted to establish the efficiency of some of the methods by experiments.

The classes of extractors experimented with include the solar extractors, those using steam, and those employing pressure under water at a temperature sufficiently high to melt the wax. We have experimented with the latter, using water alone, and also with the addition of sulphuric acid.

All experiments in extracting the wax were made with portions of one large lot of comb, and under comparable conditions. In those cases in which specific instructions were sent out by the manufacturers of the extractor, they were followed faithfully.

The study of this subject was extended to include the refining and bleaching of the wax, and also to include an indicator to find out something definite relative to the character and wax content of slumgum.

In all of this work we have been mindful of the suggestions and theories advanced by apiculturists during recent years, which was, of course, necessary in order to bring our work abreast with that of the Beekeepers' Associations and individuals. I have profited by the suggestions of some of the prominent refiners of and dealers in beeswax who kindly answered my inquiries addressed to them, but in general I have found information regarding the extraction of beeswax very scarce, at least it is very difficult to obtain.

The General Properties of Beeswax. Beeswax, when obtained from clean, fresh comb, is a tough, compact solid, having a yellowish or brownish color, a fine granular structure and a very little luster. Its taste is faint and balsamic, but the odor is honey-like and characteristic. Beeswax does not feel greasy to the touch. It loses is color, bleaches, when exposed to the action of moisture and light, some varieties with

great difficulty. The presence of a small amount of fatty matter seems to facilitate the process. The melting point of beeswax varies with different samples, due to the fact that the proportion of its constituents may vary. The melting point is higher in old than in fresh wax, i. e., the melting point increases a little as the wax ages. Yellow wax melts between 61° and 63° C. (141.8° and 145.8° F.) Its specific gravity varies from 0.96 to 0.97 at 4° C.

The average composition of beeswax is, cerotic acid, soluble in alcohol, 14.4%; myricin, insoluble in alcohol, 85.09%. There are, further, other compounds present, two hydrocarbons having been definitely recognized. The composition of genuine beeswax is approximately constant, and is not changed by natural bleaching, but chemical bleaching may increase the relative percentage of acid to 17 or 18%.

Comb Used. As the comb varied considerably, care was taken to get a fair sample for each experiment. The comb used was mostly old black comb which had been used as brood comb and was furnished by some of the beekeepers of the state and the Entomologist of the Station. The comb was sorted into three different grades; that designated as comb number one was white comb which had not been used for breeding purposes. Number two comb was light brown, which had been used as a brood comb. It was darker than number one but not as dark as number three. Comb number three was a real dark comb and had been used for breeding purposes for a long time. Almost all of the experiments were conducted with combs numbers two and three, as almost all methods are very efficient with comb like number one.

Samples. Realizing that a little difference in the samples taken for the experiments would make a greater difference in the final result, we were very careful in the sampling of the material for the experiments. The comb was cut into pieces about an inch square and placed in a pile. The pile was stirred until well mixed, divided into quarters and the two opposite quarters placed in a pile. This pile was stirred and sampled as before. This process was continued until a sample of the proper weight was obtained.

SOLAR EXTRACTORS.

Two kinds of solar extractors were used, known as numbers one and two. Number one consisted of a wooden box thirty-two inches long, eighteen inches wide, and four inches deep. At the lower end a small box is placed to hold the pan which catches the wax. Twenty-four inches from the top there is a screen to hold back the comb. The upper portion of the box is lined with tin and the waste wax and brood comb are placed in this part of the box. The box is covered with a pane of glass held in a frame which fits the upper edge of the box. The heat from the sun melts the wax and it runs down, is strained by the screen, and is collected in a pan at the lower portion of the tin.

Number two extractor consists of a wooden box sixteen inches broad, seven inches deep and thirty inches long and has legs near one end so that it can be raised up at an angle toward the sun. The interior

is fitted with a concave tin lining to hold the pieces of comb, separated by a wire cloth straining screen from the wax pan, at the lower end of the box.

These two extractors were used because it was thought they represented, as nearly as possible, the average of the solar extractors used in this country. Some beekeepers have solar extractors which are much larger than either of these, but it is doubtful if they remove a greater percentage of the wax from the comb.

The experiments conducted with the solar extractors were made, as nearly as possible, under the same conditions. They were made on the same day and within a few feet of each other, on the south side of the Chemical Laboratory, so as to get the same outside temperature.

Number one held about twice as much comb as number two. On this account, it was necessary to fill number two extractor twice while number one was filled once. The first experiments were made to determine the comparative efficiency of these two solar extractors. For number one comb, extractor number two produced on the average about one per cent. more wax; for number two comb, about two per cent. more, and for number three comb, about one per cent. more than extractor number one.

The temperature of the extractor varied so much on different days that it was very hard to tell which extractor had the higher temperature. One day number two would have a higher temperature and the next day number one would. Taking an average of all the experiments where the temperatures were taken I find extractor number two exceeded extractor number one by about 0.4°C.

Solar Extractor with Lamp. It is the practice of some beekeepers to operate a lamp, stove or furnace in connection with the solar extractor. The extractors were inclined at an angle of about thirty degrees and an inclosure built back of them, to keep the wind from blowing the lamp. A lamp was placed inside the inclosure and a hole made in the bottom of the extractor so that the flame would strike against the tin lining of the extractors.

The addition of the lamp helped the extractor to heat up in the morning, to remain warm in the evening, and on a cloudy day, to keep the extractor warm when the sun was under a cloud.

By the use of the lamp the efficiency of the extractor was increased on an average about one per cent. The best results were obtained by having the heat from the lamp strike directly under the wire screen. Often on a cloudy day the wax will run down as far as the screen and then cool. By having the heat from the lamp warm the screen and the surrounding metal the wax is kept from cooling and runs down into the pan.

Double Glass. It was thought that the addition of an extra pane of glass might increase the yield. In order to try this an extra pane of glass was placed on extractor number one with one-half inch space between the panes. It was found that the use of the second pane increased the inside temperature on an average about 9.4° C. (17° F.) It was

observed that the extractor with the double glass was slower in becoming heated in the morning and held the heat longer in the evening. The efficiency of the extractor was increased, on an average, about seven per cent. for number two comb, and two per cent. for number three comb. Number one comb was not tested.

Double Glass and Lamp. As it was shown by experiments that the use of a lamp, and an extra pane of glass increased the efficiency it was thought that a combination of the two might increase it still more. This was tried and the results showed but a slight increase over either one alone and did not come up to expectations. The increase was about 0.7 per cent.

Bleaching. It was noticed that in rendering light colored wax by means of the solar extractor the wax was bleached. An attempt was made to determine the bleaching effect of the sunlight by exposing dark wax in the solar extractor for four days. The wax was exposed for that length of time because it was thought that it would not remain in the extractor longer than that during the ordinary process of extraction. Some dark wax which had been obtained from the Ferris steam extractor was placed in solar extractor number one and melted for a day. A sample of this wax was taken and the remainder remelted. This was continued for four days and samples were taken at the end of each day. At the end of the fourth day the samples were compared and it was impossible to note any change in the color of the wax.

Some dark wax which had been boiled with sulphuric acid was placed in solar extractor number two and melted. It was sampled and remelted the same as in the preceding experiment. It was impossible to notice any difference in the shade or color of the wax.

Slumgum. In order to see if the solar extractor could remove wax which the steam extractor was unable to remove, some slumgum from the Swiss extractor was put in solar extractor number two and heated for four days. The weather was very warm and at the end of the fourth day there was not a trace of wax to be seen in the extractor.

Honey. A number of experiments were made to see if the solar extractor could be used to remove honey from the comb. In the experiments conducted with the dark comb in warm weather, the honey obtained was dark and thick, had a scorched taste and could not be used for anything except feeding purposes. In the other experiments with light colored comb and with moderately bright sun the honey was light colored and of good quality.

Soaking Comb in Water. Some beekeepers make a practice of soaking the comb in water before putting it in the solar extractor, supposing that the soaking loosens the cocoons and dirt in the comb. Some number two comb was soaked in water for six days and put in solar extractor number one. Some comb which had not been soaked was used as a check, and the soaked comb showed an average increase of about one per cent. over the unsoaked.

Comb Soaked in Dilute Sulphuric Acid. It was thought that the soaking of the comb in dilute sulphuric acid might loosen the dirt and

cocoons and leave them in a free condition. Some number two comb was soaked for three days in a solution of five per cent. sulphuric acid, washed to remove the acid and treated in solar extractor number one for three days. Some comb which had not been soaked was used as a check, and the comb treated with acid gave on an average about five per cent. more wax than that not treated. Care had to be taken to wash all of the acid out of the comb before it was put in the extractor on account of the action of the acid on the metal linings of the extractor.

STEAM EXTRACTORS.

In determining the efficiency of the steam extractors three kinds were used, the Ferris, the Root-German, and the Swiss. The Ferris extractor was loaned to the department by Mr. M. A. Gill of Longmont, Colorado, and the Root was loaned by Mr. R. C. Aikin of Loveland, Colorado. The Swiss was obtained from the Station Entomologist.

The Root-German Extractor. This extractor was made by the A. I. Root Co., Medina, Ohio, and consisted of a small sheet iron tank or can with a false bottom. On an iron frame above the false bottom rests a wire basket. Pressure is applied by means of a screw which runs through the cover of the machine. Water is placed in the bottom and the machine placed on a stove. The steam, as it generates, rises through a hole in the middle of the false bottom, which is covered by a deflector. The comb, not too much, is placed in a burlap bag and the bag is placed in a metal basket which is put into the extractor. When the comb becomes thoroughly melted pressure is applied by means of the screw, increasing at intervals and not applied all at once. After most of the wax has been removed it is a good thing to remove the pressure, stir the slumgum and press again. With old comb it is best to stir and press at least two or three times. This extractor worked in a very satisfactory manner and the results show the efficiency of the Root extractor to be greater than that of any of the other steam or solar extractors.

The Ferris Steam Wax Extractor. This extractor was invented by Mr. C. C. Ferris of Richfield Springs, New York, and was the first extractor put on the market which used pressure in connection with steam as a means of extracting beeswax. The extractor consists of a galvanized iron tank in which are suspended two extra heavy galvanized wire-cloth baskets. Comb is placed in the baskets, water is put in the lower portion of the machine and the whole is placed on the stove. The steam as generated, passes upward into the baskets and melts the wax which runs down the inclined bottom and out the spout into a pan containing water. After part of the wax has melted pressure is applied in the basket by means of a screw and the wax is forced out of the comb while it is kept hot by steam. The comb is then stirred, heated and pressed again.

The Ferris extractor worked very well on number one comb, but it did not give good results with either comb numbers two or three. The machine was not made strong enough so that sufficient pressure could be applied to force all of the wax out of the comb. The screws for applying the pressure were too small and the method of fastening them not

very secure. The results show that on an average the efficiency of the Ferris extractor is about one per cent. below the Root extractor for number two comb and about twelve per cent. below for comb number three.

The Swiss Steam Wax Extractor. This extractor is made in two sections. The lower one is an ordinary can and contains water. The upper section has a bottom in the shape of an inverted funnel and rests on the lower one. Inside the upper section is placed a basket made of galvanized wire-cloth. The wax is placed in the basket and the machine placed on the stove. Steam is generated in the bottom, passes up through the hole in the center of the funnel shaped bottom of the upper section and comes in contact with the comb in the basket. The wax in the comb melts and runs down and out of a spout into a pan containing water. The Swiss extractor was used without pressure and the result shows an increase in efficiency caused by the use of pressure in wax extraction. The Swiss extractor can be used in connection with a press by putting the comb in a sack and transferring it to the press, but this method gives the wax a chance to cool and is not as efficient as some of the others.

Remelting Test. The results given above are for the wax as it comes out of the extractor. It was thought that it might be well to determine the amount of dirt in the different samples of wax. The wax used was that obtained in some of the preceding experiments with the Ferris, Swiss and solar extractors.

The wax obtained from each extractor was broken into small pieces, the sample thoroughly mixed, and a separate portion weighed and remelted in each of the four extractors. The wax from the steam extractor was allowed to drop from the spout into a dish of water on a water bath. The heat of the water in the water bath kept the wax melted and the dirt settled to the bottom. Owing to the lateness of the season the wax in the pans of the solar extractors did not remain melted. To have the conditions as near as possible the same as in the steam extraction, the wax from the solar extractors was put in a dish on the water bath, heated and the dirt allowed to settle. In both cases the dirt which had settled to the bottom of the cake was trimmed off and remelted over a water bath. This process was continued until all of the dirt was removed. The percentage of clean wax obtained was, for the solar extractor number one, 94.66, the solar number two, 96.19; the Ferris, 96.31, and the Swiss, 94.38.

Pressing Under Water. The comb, with some water, was put in a tub on the stove and the wax allowed to melt, but not to boil. A can was placed under a press and a slatted follower placed in the bottom of the can. Above this was placed a burlap bag and the hot water, melted wax and comb were poured into the bag, the top of the bag folded over, a slatted follower placed on top and pressure applied by means of a screw. After some of the wax had been forced out, the water and wax were drawn off, the pressure relieved, the slumgum stirred, hot water added and pressure applied again. The can, which fits under the press, has two holes which are stopped by corks. One is at the bottom and the

other near the top. By pulling the cork out of the upper hole the wax which has risen to the top can be drawn off and by using the lower hole all of the wax and water can be removed. The whole apparatus must be kept as warm as possible. An inside can with holes in the sides was tried but did not give good results.

In the following, average results are given because in the first two trials some of the wax adhered to the bag and follower. This method proved very efficient, giving about one per cent. more wax than the Root extractor with number two comb and about six per cent. more with number three comb. The main points in this method were received from Mr. Gill of Longmont, Colo., whose method is somewhat similar except that in his case the wax was dipped from a boiler and placed in the press.

Sulphuric Acid and Pressure Under Water. It was thought that the addition of acid to the water in the experiment might increase the efficiency of the method. The comb was heated in a porcelain lined tub with a solution of five per cent. commercial sulphuric acid. When the wax had melted it was poured into the sack in the press and pressure applied quickly in order not to have the acid in contact with the metal any longer than necessary. The wax and water were drawn off, boiling water added, the slumgum stirred and pressure applied again. This water was drawn off and put with the rest. As this was an experiment to determine the efficiency of the press a tin can was used, but in practical work it would be necessary to have everything acid proof, as hot acid even when diluted, is very destructive to most substances. The can could be made of wood or porcelain lined ware. The latter would probably be the better.

This method was easy to manipulate and rapid and was the most efficient of all the methods used. This method gave about seven per cent. more wax for number two comb and seven per cent. more for number three comb than did the Root extractor.

Comparison of Different Methods. The following table shows the efficiency of all methods with combs number two and three and are average results. Number one comb was not used in all the extractors because most methods give good results with new clean comb:

	Result in Percent.	
	Comb. No. 2	Comb. No. 3
Solar extractor, single glass	31.02	10.24
Solar extractor, double glass	38.27	12.79
Swiss steam extractor	48.59	21.30
Ferris steam extractor	58.02	25.60
Root steam extractor	59.43	37.83
Pressure under water	60.55	44.42
Pressure under water with sulphuric acid	67.02	45.19

COLOR OF THE WAX.

The wax produced by the Root, Ferris or Swiss extractor did not have a good color and would have had to be refined before it could be used. The wax from the solar extractors was always a better color than

that from the steam extractors. The wax formed by pressure under water was nearly as good in color as the wax from the solar extractors. The wax obtained by pressure under water containing five per cent. of sulphuric acid was very good in color, in fact, almost as good (with combs number two and three) as most of the wax obtained from the solar extractors.

I believe the color of the wax from the steam extractors to be due to the presence of iron, owing to the metal in the extractor coming in contact with the steam. The wax from the Ferris and Root extractors was tested and showed the presence of small quantities of iron; enough perhaps to account for the color. The wax from the solar extractors did not show the presence of any iron.

Bleaching Wax. In a search for a method for bleaching beeswax I found many compounds which would effectually bleach the wax, but most of them either destroyed the wax or were in themselves poisonous. Chlorine, which is a great bleaching agent, cannot be used on account of its forming, according to Allen, chlorination substitution—products which may give rise to hydrochloric acid. Beeswax can be volatilized almost without change in a vacuum but when distilled under ordinary pressure it yields a variety of products. Therefore this method cannot be used in purifying beeswax.

The principal use of beeswax is in the manufacture of comb foundation which is given to the bees to act as a foundation on which to build their comb. In order to get nice, white honey the foundation must be light colored. The following experiments were made to determine the best method for cleaning and bleaching wax.

Acids Used in Bleaching. The beeswax on which this experiment was made was a sample of wax that had been rendered from dark colored comb. It was heated in water so as to get a uniform cake, which was cut into eight equal pieces and one piece taken for each test.

Piece number one was heated with 2 cc. of sulfuric acid and 200 cc. of water. Piece number two was heated with 2 cc. of hydrochloric acid and 200 cc. of water. Piece number three was heated with 2 cc. of nitric acid and 200 cc. of water. Piece number four was heated with 200 cc. of water. Piece number five was heated with 200 cc. of water and 2 cc. of a solution containing 60 cc. of sulfuric acid and 63 grams of potassium bichromate to 1000 cc. of water. Piece number six was heated with 200 cc. of water and 5 grams of sodium chloride or common salt. Piece number seven was heated with 100 cc. of the solution of sulfuric acid and potassium bichromate which was used with number five, mixed with 200 cc. of water. They were all cooled in the air and stood over water while cooling. Number one gave the best results and the wax was lighter colored than any of the others. Numbers two, three, five and six did not show much improvement over number four which was used as a blank for comparison. Number seven gave a very dark green wax.

This would go to show that as far as bleaching and removing the coloring matter, the sulphuric acid gives the best results of the materials used.

Sulphuric Acid and Hydrogen Peroxide. For this experiment a sample of dark wax which had been obtained from brood comb was used.

It was melted in hot water, formed into a cake, the cake cut in eight equal pieces and the pieces treated in the following manner:

Piece number one was heated with 100 cc. of water.

Piece number two was heated with 100 cc. of water and 2 cc. of sulfuric acid. Piece number three was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number four was heated with 100 cc. of water, 10 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number five was heated with 100 cc. of water, 15 cc. hydrogen peroxide and 2 cc. of sulfuric acid. Piece number six was heated with 100 cc. of water, 20 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number seven was heated with 100 cc. of water, 25 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number eight was heated with 100 cc. of water and 5 grams of oxalic acid. Piece number three, heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc of sulphuric acid, was much better than any of the others. Hydrogen peroxide was tested for and found in the water in which the wax had been melted. Excessive boiling with water seemed to injure the grain of the wax, but the heating with water and sulfuric acid and with water, sulfuric acid and hydrogen peroxide did not seem to injure the grain. Piece number eight showed only a slight improvement over the original sample.

Remelting with Sulphuric Acid and Hydrogen Peroxide. One-half of piece number three of the last experiment was remelted in 100 cc. of water, 2 cc. of sulfuric acid and 5 cc. of hydrogen peroxide. The color of the wax was very much lighter than before being remelted in 100 cc. of water, 5 cc. of hydrogen peroxide and 5 cc. of sulfuric acid. The wax was pressed out of the cloth and was very much improved. It had a golden yellow color and a good grain.

Increasing the Amount of Sulfuric Acid. The wax used in this experiment was dark and was obtained by rendering old combs. It was remelted and divided into eight equal parts. Number one was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Number two was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 5 cc, of sulfuric acid. Number three was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 10 cc. of sulfuric acid. Number four was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 15 cc. of sulfuric acid. Number five was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 20 cc. of sulfuric acid. Number six was the same as number five except that it was heated with 25 cc. of sulfuric acid. Number seven was inclosed in a canton flannel bag, heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc. of sulfuric acid, and the wax squeezed out of the bag. Number eight was heated with 100 cc. of water. Number two gave better results than any of the others with the exception of number seven, which gave a very nice yellow wax.

Refining with Alcohol. The wax taken for this experiment was obtained by rendering old brood combs and was dark. It was remelted and divided into eight pieces. Number one was heated on the water bath with 100 cc. of barrel alcohol. Number two was heated on the water bath with 50 cc. of alcohol and 50 cc. of water. Number three was heated in the same manner as number two with 25 cc. of alcohol and 75 cc. of water. Number four, one-fourth of number one, was heated in water. In number one the wax dissolved and on cooling cerotic acid separated from the alcohol. In numbers two and three there did not seem to be any cerotic acid dissolved in the liquids. Number one gave a soft waxy substance, probably myricine. Number four gave a compact substance. Number five was as good in appearance and texture as any of the others. I could not see any improvement in the color of the wax caused by the treatment with alcohol.

The use of Cloth in Refining Wax. The wax used for this experiment was very dark and was divided into four equal parts. Piece number one

was inclosed in a piece of fine canton flannel cloth and heated in water which contained five per cent of sulfuric acid and five per cent of hydrogen peroxide. Number two was inclosed in a piece of fine canton flannel and heated in a solution of five per cent sulfuric acid. Number three was inclosed in a piece of coarse linen cloth and heated in a solution containing five per cent sulfuric acid and five per cent hydrogen peroxide. Number four was inclosed in a piece of fine canton flannel and heated in water. Number one gave the best results. The wax had a good color and a good grain. Number two was next to the best. Number three was not as good as either number one or number two. Number four was used as a check. All showed improvement over number four.

One-half of number one was placed in a canton flannel cloth and heated with a solution containing five per cent sulfuric acid and five per cent hydrogen. One-half of this last sample was placed in a canton flannel cloth and heated twenty minutes with a solution containing two per cent sulfuric acid and five per cent hydrogen peroxide. Three-fourths of the last sample was placed in a canton flannel cloth and heated with a solution containing five per cent hydrogen peroxide and two per cent sulfuric acid. The last sample was remelted in the same manner and the color could not be improved. The last two heatings did not seem to improve the color of the wax. The one before them, number two, gave the best colored wax and the wax had a good grain.

EXAMINATION OF THE SLUMGUM.

As stated under the properties of wax, the wax contains on an average of about 14.4% cerotic acid. There are two ways known for the determination of pure wax in impure beeswax. They both depend on the amount of cerotic acid in the wax which can be saponified in the presence of wood alcohol. Neither method is very satisfactory for dark colored wax. The amount of cerotic acid in the slumgum might be determined by one of these methods and the amount of wax in the slumgum estimated.

All of the slumgums gave cerotic acid and therefore contain some wax. I was unable to devise any method or modification of methods to determine the amount of cerotic acid in the slumgum. In the presence of so much coloring matter the indicators did not give good results.

Boiling with wood alcohol and decanting off the hot solution and titrating was tried, but was unsatisfactory. It was found that after boiling ten grams of slumgum with twelve portions of wood alcohol of 50 cc. each there still remained cerotic acid in the residue. The addition of hydrogen peroxide to the alcohol and slumgum did not cause an improvement. A red coloration was formed which covered the end reaction of the indicator.

SUMMARY.

In summing up the facts given in the preceding experiments, I draw the following conclusions:

In some ways the solar extractor is a good extractor for the beekeeper to have. It is convenient and requires very little attention. The solar extractor does not remove as much wax from the comb as the steam extractor. The residue, or slumgum, from the solar extractor may be worked over in the steam extractor and some wax obtained. The solar extractor can remove honey from the comb, but with ordinary comb and warm weather the honey is not of a very good quality.

The heat of the sun seems to bleach some kinds of wax, besides extracting it from the comb. In other cases it is difficult to notice any bleaching in wax which is exposed to the sun.

The steam wax extractor removes more dirt than the solar extractor. The steam extractor will remove honey from the comb, but the honey is usually very dark. In efficiency the steam extractor has an advantage of from ten to twenty per cent over the solar extractor.

In efficiency the solar wax extractor number two has a slight advantage over solar extractor number one, about one per cent for number one comb, for number two comb two per cent, and for number three comb about one per cent.

The addition of an extra pane of glass to the solar extractor raised the inside temperature on an average of 17 degrees F. The efficiency of the extractor was increased on an average about seven per cent. for number two comb and two per cent for number three comb.

The addition of a lamp to the solar extractor raised the efficiency of the extractor on an average about one per cent.

The addition of a lamp to the double glass extractor did not increase the efficiency of the extractor over 0.7 per cent.

Soaking the comb in water before using the solar extractor increased the yield of wax on an average, about one per cent.

The soaking of the comb in dilute (5 per cent) sulfuric acid increased the yield about five per cent over that not treated.

Of the steam wax extractors, the Root proved the best. The results show that for the same comb, number two, the Root produced one per cent more than the Ferris and ten per cent more than the Swiss.

Pressure applied to the comb under hot water gives a larger per cent wax than when the comb is pressed in steam. Heating with dilute sulfuric acid and pressing under water gave the best results. For number two comb this method excells in efficiency the single glass solar extractor by thirty-six per cent., the double glass solar by twenty-nine per cent., the Swiss steam wax extractor by eighteen per cent, the Ferris steam wax extractor by nine per cent, and the Root steam wax extractor by over seven per cent.

For number three comb, heating with dilute sulfuric acid and pressing under hot water, excells the single glass solar wax extractor by thirty-five per cent, the double glass solar wax extractor by about thirty-two per cent, the Swiss steam wax extractor by twenty-four per cent, the Ferris steam wax extractor by nineteen per cent, and the Root steam wax extractor by seven per cent.

The above shows that the slumgum from 100 pounds of wax treated by the ordinary solar wax extractor will retain from thirty-four to thirty-six pounds of wax, which can be removed by heating with dilute sulfuric acid and pressing under hot water. If the Root extractor, which is the best

of the steam wax extractors, is used there remains in the slumgum about seven pounds of wax which is obtainable by the use of the sulfuric acid and pressure. With the price of wax at twenty-five cents a pound it would pay to buy old slumgum and remove the wax by this method.

The method of heating the wax, while inclosed in a bag, with sulfuric acid, as practiced by more refiners of wax, gives good results.

Sulfuric acid seems to be better for bleaching wax than either hydrochloric acid, nitric acid, or a mixture of potassium bichromate and sulfuric acid. The wax from the latter has a dark green color which may be removed by repeated heating with oxalic acid. Oxalic acid is a poison and I am not prepared to state how much would be left in the wax or what effect it would have upon the bees working with the wax.

An increase of sulfuric acid above five per cent does not seem to improve the color of the wax.

The addition of five per cent of hydrogen peroxide to the sulfuric acid and water gives a much lighter colored wax. An increase of hydrogen peroxide above five per cent does not give an improvement in the color of the wax.

Common salt added to the water in which the wax is boiled does not cause the dirt to settle enough to show a change in the color of the wax.

Heating the wax, which has not been treated with sulfuric acid and potassium bichromate, with oxalic acid does not seem to improve the color of the wax.

Excessive boiling seems to injure the grain of the wax. The best results in regard to the grain of the wax were obtained by causing the wax to melt but not come to a boil.

Heating the wax while inclosed in a cloth and squeezing it after the wax has melted gives a much better colored wax than heating without the cloth. A fine canton flannel cloth with the nap inside is better than a coarse cloth. The nap seems to hold the dirt that is in the wax. Remelting the wax inclosed in a cloth with two per cent. solution of sulphuric acid and five per cent. hydrogen peroxide improves the color of the wax. Continued treatment in the same way does not give corresponding improvement in the color of wax. After the third treatment there is not any improvement in the color and rather a deterioration in the quality of the wax.

Boiling with concentrated and dilute alcohol does not improve the color of the wax.

The color of the wax is not improved by standing over water after cooling.

All of the slumgum retains some wax, but it was found impossible to determine the exact amount.

From the results of these experiments and my own experience in handling bees and rendering wax I believe that it is best for the average beekeeper to have a large solar wax extractor, heated by some artificial heat, by means of which most of the wax in the lighter colored combs, cappings, and burr combs may be easily rendered. The dark combs may also be treated in this manner and the slumgum stored in barrels until the beekeeper has time to treat it with dilute sulphuric acid and press under water. This method is quick and efficient. If the wax has to be refined it can be done by heating, while inclosed in a canton flannel sack, with a solution containing five per cent. of hydrogen peroxide and two to five per cent. of sulphuric acid. Both of these chemicals can be bought at the ordinary drug store. The common kind, commercial, should be used.

In mixing the acid and the water care should be taken to always pour the acid gently into the water and not the water into the acid.

The cost of the chemicals compared with the results obtained is very slight.

Bulletin 130 May 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

The Evergreen Trees of Colorado

BY

B. O. LONGYEAR

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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THE EVERGREEN TREES OF COLORADO

By B. O. LONGYEAR

At no time in the history of our country have matters pertaining to our forests been of such general interest as at the present. Such interest is certainly justified when we consider the fact that between three and four times as much timber is used by us each year as our forests can grow in the same length of time. Many of the materials which a few years ago were expected to become substitutes for wood have failed to meet the requirements in many ways. Moreover the continued use of wood for new purposes more than offsets the saving by these substitutes. Hence there is not only apprehension for the future supply of wood but even now certain great industries are being forced to limit their operations because of the scarcity of timber. This is particularly true of the timber from which paper pulp is manufactured.

In Colorado the principal drains upon the timber resources of the state have been to supply material for mining timbers, telegraph poles, railroad ties, fence posts, bridge timbers and native lumber. The growing scarcity of our timber trees is being emphasized by the rapid advance in price which is now felt in all industries requiring such material.

So long as the forests have been left to the disposition of private interests the forests have suffered greatly. The wasteful and careless methods of lumbering that have usually been employed in this country have frequently been followed by the consuming fire fiend. In these ways the larger part of our forest products have often failed to reach the markets but have served to darken the skies with the smoke of a sacrifice in which the gods have no pleasure. Not only have the trees themselves been destroyed but in many cases the burning away of the humus, the slow accumulation of centuries, has laid bare the very rocks and made reforestation impossible. But this is not all. The rapid and complete removal of the forests has in many places shown how great was their influence upon water movements. Thus with the removal of the forests that once surrounded the headwaters of our great streams, disstrous floods in spring and low water in summer have indicated the regulating effects which these forests once produced. In our own state the forests in the higher altitudes serve to check in spring the rapid melting of snow which has drifted among the trees and thereby lengthen the period of stream flow during the growing season.* The most important effects of the forests in this connection, however, are due to the character of the forest floor, which is

* For some of the effects see Bulletin 55, Colo. Exp. Sta.

composed of the decayed, castoff parts of the trees themselves. This layer of humus material possesses the ability to absorb water like a sponge and in this way check the rapid surface flow of water such as takes place on bare soil. Thus the water from melting snows and from heavy rains is held back to appear later from springs instead of rushing into the streams and giving rise to floods and high water.

NATIONAL FOREST RESERVES.

The extent of the forest reserves in this country indicates the importance which the government places upon the conservation of the forests. The first national forest reservation was established in 1891. On April 1, 1907, the total extent of the forest reserves in the United States comprised one hundred and fifty-three reserves with a grand total of nearly one hundred and forty-eight million acres. California stands at the head of the list with an area of nearly twenty-two million acres, while Colorado comes fifth with eighteen reserves covering nearly sixteen million acres. These vast tracts have not been set aside, however, to become unproductive holdings of the National Government. They are not even closed to the would-be settler on any agricultural lands within their boundaries nor to the prospector and miner in seeking and developing claims. Grazing lands within the forest reserves can still be used as such with the added protection to the industry which the small fee carries with it. Neither is it the primary object of the forest reserve idea to stop the cutting and sale of timber but to regulate it in such a way as to make the forests more productive. In fact, the primary purpose is to prevent wasteful and destructive practices of lumbering, to protect the forests from fire, their most destructive enemy, and to get them in a condition where reforestation may go on and thus make them a perpetual source of timber supply.

The principal forest trees of this state are those commonly known as evergreens. It is the purpose of the present bulletin to help familiarize the people of this state with our native evergreen trees and thereby strengthen the interest in their protection. Brief suggestions and directions are also given for their use in ornamenting the home grounds and in planting for wind-breaks and screens.

THE EVERGREENS.

In popular usage the term evergreen is applied to members of the pine or cone-bearing family of trees. This is due to the fact that most members of this family hold each season's crop of leaves during several years so that at no time are they bare of foliage. Some true cone-bearing trees, however, such as the larches, shed all their leaves each autumn the same as other deciduous trees. On the other hand, some of the broad-leaved trees and shrubs hold

their foliage in a green state over winter or even longer and are therefore true evergreens. This is particularly the case in tropical countries. But as all the cone-bearing trees of this state are evergreens the term as here used is intended to include members of the pine and juniper families only.

The plants of the pine family are chiefly characterized by the fact that their seeds, instead of being contained during all stages of growth in wholly closed seed cases, as in other seed-bearing plants, are at first born naked on the scales of cones. The scales of these cones become dry and more or less woody and hard according to their thickness and form the familiar dry, scaly cones of such trees.

Another character common to the plants of the pine family in this region is found in their needle-shaped leaves. These leaves, on account of the relatively small surface which they expose and the thickness of the epidermis which covers them, are well adapted to endure the drying effects of winter so trying to all kinds of perennial plants.

Most of the cone-bearing trees are possessed of a resinous juice or sap which often exudes from wounds and slowly hardens in the form of drops or masses of pitch. This material, when gathered from certain pines in the southeastern states, constitutes the crude turpentine from which the spirits of turpentine of commerce is obtained, the common resin or rosin being left as a residue. Timber from pine trees in which the wood has become saturated with the pitch of the sap possesses great durability in contact with the soil.

In most species of cone-bearing trees the two sorts of flowers, which are separate, occur on the same trees. The stamen flowers, those which produce the pollen, are crowded in small catkins or cone-like clusters near the ends of the branches. (Plate II, 1.) The pollen, in the form of a yellow powder, is abundantly produced and is carried by the wind to the young pistillate or seed-bearing cones. In the vicinity of extensive spruce and pine forests this pollen powder is often so abundant, during the blossoming period, as to lend the impression that a shower of sulphur has occurred. Soon after the pollen is shed these little cones dry up and fall off, hence are not commonly noticed.

The pistillate or seed-bearing cone consists of an axis upon which are fastened the scales. The scales vary much in shape and texture in different species and furnish some of the principal characters by which the species are distinguished. At the base of each scale of the young cone, and lying attached to its upper surface, is a pair of ovules. During the flowering period the young cones point upward with the scales spread apart. This allows some of

the pollen grains, with which the air may be filled at this period, to slip down to the base of the scales, where they come in contact with the waiting ovules. In a few days the scales close together and the process of fertilization later takes place. This is soon followed by the growth in size of the cones and the development of an embryo within each ovule by which it becomes a seed. (Plate I and II A.)

In some species, e. g., the pines, the scales of the cones remain closed during the whole of the first year and mature their seeds in the second year. In others, such as the spruces, the seeds are matured and dropped at the end of the first season.

In the juniper family, which is closely related to the pine family, these seed-bearing scales become fleshy and united as the cones ripen so that the matured seeds are found imbedded in the pulp of the berry-like fruits.

TRANSPLANTING EVERGREENS.

The root system of the cone-bearing trees is often very extensive, especially in trees that have reached some age, and have grown all their lives undisturbed as in nature. The roots are, moreover, very sensitive to drying and, on account of the resinous character of the sap, when once dry they cannot be revived by soaking. Then, too, an evergreen always has leaves which are continually giving off some moisture, hence at no time can these trees be without moisture at the roots without suffering injury. These facts usually account for the lack of success which so many persons experience in transplanting evergreens. The writer has seen young evergreen trees that had been carelessly dug or even pulled from the soil among the hills, where they had become deeply rooted, and then carried for miles with no protection whatever to the roots. A cottonwood, boxelder or black locust might survive such treatment, but an evergreen should never be expected to grow when handled in this manner.

USE OF FOREST GROWN SEEDLINGS.

The fact that the roots of evergreens are usually slender and that they quickly extend with but little branching to considerable distances, when undisturbed, makes the transplanting of forest grown trees an uncertain matter. This is especially true when trees of some size are being moved by the usual methods. Native forest seedlings are, however, often made use of in forest planting and the same can be done for other uses providing that the small seedlings only are moved. The best time for this work is just as the buds are beginning to swell in spring but before the new growth is out. Somewhat later transplanting can, however, be done with extra care. Such seedlings should not be over ten inches in height

to bear transplanting well, and smaller sizes are better. They should be carefully lifted from the soil with a spade in such a way as to retain as many of the roots as possible. A pail or tub with two or three inches of thin mud or puddle in the bottom should be at hand, into which the roots of the little trees are to be at once placed. If they are to be planted again in a few hours the seedlings may be carried in this condition. But where large numbers are being gathered and where a considerable journey is necessary, the trees may be closely packed, roots down, in boxes, using moist sphagnum moss, fine grass or similar material among the roots. The boxes should be covered, if placed in an open vehicle, for the journey. If the trees are not to be planted out at once they may be heeled in for a few days. This consists of placing the roots in a broad trench with the trees leaning against one side, after which moist soil is shoveled over them until the trees are about half buried. A shady place should be selected for this purpose.

Trees of such small size are usually grown for two or more years in nursery rows or until one to two feet high. In this way they can usually be given much better care than when placed in the wind-break or other permanent quarters. They should be planted in rows about eighteen inches apart and six to eight inches apart in the row for the small sizes.

Transplanting is best accomplished by laying a wide board upon the surface of the soil and then opening a trench along one edge with a spade. The little trees are then planted against the perpendicular side of the trench and moist soil firmly packed about the roots. The trench should be made only a few minutes before planting to avoid drying of the soil, and the trees should be carried in a pail containing a little water. If possible, select a cloudy day for this work and when the soil is moist but not wet. The soil should not be allowed to bake at any time. Careful cultivation must be maintained during the earlier half or two-thirds of the growing season and a winter mulch of coarse manure or straw is desirable.

In transplanting larger trees the same care must be observed as with small ones. It is often possible, in moving them only a short distance, to retain the earth surrounding the roots in a ball. Thorough packing of the soil about the roots should be practiced except where the soil is very sticky or wet.

It is usually desirable to give the nursery partial shade during the first season. This may be accomplished by lath screens supported on stakes about one foot high. Brush laid across wooden bars or wires stretched along the rows may also be used.

NURSERY GROWN STOCK.

This is always to be preferred where only a few trees are

wanted and where one has no time to grow them from seedlings. Nursery grown trees, if properly handled, have been transplanted one or more times. This causes the root system to thicken up, or become condensed in a relatively small space, and thus makes it possible to secure practically all of the roots in a compact mass when dug. Some nurserymen, who make a specialty of growing evergreen stock, furnish trees each with a ball of earth which contains most of the roots and enables one to plant them with confidence. Trees up to eight feet in height may in this way be safely shipped and transplanted, but, of course, they are correspondingly expensive.

Nursery grown seedlings four to ten inches high and one to three years old can be purchased in quantity from the leading nurserymen and are often cheaper than forest grown seedlings if one considers the time and labor required to obtain the latter. Nursery grown stock, whether in seedling or larger sizes, is usually cheaper in the end than forest trees for, not only are the trees more apt to live, but, having been adapted to conditions in the open, they are surer to make a rapid and healthy growth.

THE PROPER TIME TO TRANSPLANT EVERGREENS.

It is generally recommended that evergreens are best transplanted in spring. This is particularly the case in a climate like that which prevails in Colorado. Fall planting is claimed to be satisfactory by some nurserymen and it may prove successful in other climates. But the lack of soil moisture which often prevails here in the winter season, together with the drying winter winds, makes fall planting a very hazardous undertaking. Trees of this class will often bear later transplanting than other kinds. The proper time, however, is when the buds are swelling, as at this time the vital processes of the tree are just commencing. Hence new root growth is taking place which will enable the tree to secure water from the soil and to become established.

PRUNING.

It is seldom necessary to prune carefully dug nursery grown evergreens, when they are transplanted, unless it is desired to change their shape. The same is true of seedling trees, even forest grown.

In transplanting forest grown trees of more than one foot in height it may be desirable to cut back the limbs one-third to reduce the loss of moisture from the leaves.

It is best to preserve the terminal bud, as this gives rise to the leader or main stem. If by any means this bud is destroyed it sometimes occurs that two or three of the next lower whorl of buds will push up equally strong shoots. In this case all but one should

be pinched back or cut off and the remaining one be tied erect to the stub of the leader.

EVERGREENS ON THE LAWN.

Among the evergreen trees of Colorado are to be found some of our most ornamental trees for the home grounds. If rightly placed and properly planted so as to secure a healthy growth they are capable of adding, not merely to the foliage effects of summer, but they also lend a pleasing touch of green to the winter landscape.

They are best situated along the borders of the grounds, where they may form a background for shrubs and flowering plants. Specimen trees should not be freely used, as a rule, except on large grounds. They should be placed at a sufficient distance from other trees so that they can spread out naturally. If planted in sodded ground the sod should be removed and a circle of bare earth four or five feet across, kept well cultivated around each tree for several years. A great many evergreen trees, as well as other kinds, are needlessly lost every year by planting them in sod where they must compete with the grass.

In the pruning of old trees one should hesitate to cut off the limbs close to the trunk if it is expected that new ones will start out as in many of the deciduous trees. The usual manner of pruning evergreens up from the ground for several feet is much to be deplored, especially in the case of specimen trees on the lawn. The beauty of most evergreens in such situations is dependent on their being allowed to develop a natural form with the lower branches extending clear to the ground. This practice of trimming off the lower branches is most often due to planting evergreens where they eventually shut off the light or the view. Thus it is advisable to plan well in advance the position of each tree about the house and to take into account the effects of future growth. If trees of this class are planted on the south side and close to the dwelling there will eventually be an undesirable shading of the house in winter on the side where the sunshine at that season is most available.

Then, too, the planting of evergreens before the front windows is sure in time to give rise to the necessity of trimming the trees up from the bottom, removing them entirely or else leaving them to darken the rooms and obstruct the view. Where privacy and seclusion are sought, however, evergreens are well suited to such purposes. Thus they may be used to screen or hide unsightly places or objects and are splendidly adapted for planting around outbuildings.

EVERGREENS FOR WINDBREAKS.

Evergreens are among the most effective trees for windbreaks. They are especially desirable for giving shelter from cold winds in winter to sheds and barns and yards for stock. They are also desirable to plant around the outside of the deciduous timber plantation to check the sweep of winds which carry away the snow and fallen leaves. Seedling trees which have been twice transplanted and are about one foot high are of a suitable size for this purpose. They should be set far enough apart to allow each tree to spread out without crowding and eventual loss of the lower limbs. Eight or ten feet apart is about as close as such trees as pines and spruces should be planted. If more than one row is used the trees should alternate in the rows and the rows be at least twelve feet apart. Where a low hedge-like effect is desired much closer planting may be done, and the trees cut back when at the proper height.

Thorough cultivation is needed until the trees are well established or as long as there is sufficient room between the rows.

Evergreens can often be established with good results among deciduous trees planted for windbreaks. In fact, many species of evergreens cannot be readily grown during the seedling stages except in partial shade, hence the desirability of shading the young plants in the nursery.

Close shading, however, should not be allowed to continue after the trees have reached a height of four or five feet. Otherwise the trees are apt to lose their lower branches and become spindling, thus greatly reducing their effective windbreak character. If the surrounding trees become too tall and dense they should be thinned out or cut back to give the slower growing evergreens a better chance.

RAISING EVERGREENS FROM SEED.

This is work which is most successfully undertaken by nurserymen or other persons of experience. For those who have time and the necessary patience to wait for several years while the seedlings are growing this is not only a cheap way to secure a large amount of stock, but is also very interesting work. Seeds of most evergreens can usually be purchased from the large seed houses. Where possible, however, it is desirable to save them from native or local growing trees which show the best color, form and hardiness. Seeds of the pines and spruces are best harvested by gathering the cones a little while before they open. When dry, in most cases the scales spread apart and allow the seeds to be readily threshed out. The cones of the lodge pole pine, however, often do not open unless heated to 100 to 150 degrees

Fahrenheit. This may be done on a wire screen placed above a stove, or in an oven.

In the case of junipers and red cedars the berries when ripe should be gathered and soaked for twenty-four hours in strong lye made from wood ashes, and rubbed on a fine sieve to remove the pulp. They should then be stratified by mixing them with moist sand which is to be kept in a box or other receptacle left where freezing will take place. They will not usually grow until the second season.

The seed bed for raising conifers should be on light, porous soil with good underdrainage, but which can be kept from drying out. If only a small number are to be grown good garden soil can be suitably prepared by mixing a considerable proportion of fine sand with the surface two or three inches. If the soil is naturally sandy this would not be necessary.

Beds about four feet wide may be laid off and the seeds sown broadcast or in drills or rows, scattering them about as thickly as with radish or onion seed, for the smaller kinds, and about one inch apart for the larger kinds. The planting is usually done in May, the seeds being covered to a depth of ¼ to ½ inches, depending on their size.

If the soil is at all heavy or loamy in character a layer of fine sand should be scattered over the bed to a depth of one-fourth inch. The soil should be moist but not wet when the seeds are sown and the surface must be kept finely pulverized. Where the atmosphere is very dry it is often possible to retain the soil moisture by covering the beds with burlap fastened down with pegs. This will admit the sprinkling of the beds with a watering pot without washing the soil or disturbing the seeds. The burlap covering must be removed as soon as the seedlings begin to break through the soil.

Most evergreens require partial shade during the first two or three years of growth from seed. This is usually accomplished by means of lath screens placed six feet above the beds, the lath being laid about one and one-half inches apart. In place of lath brush may be used laid on a framework of poles supported on posts of the proper height. Although free circulation of air must be given across the evergreen seed bed the seedlings should be protected from strong winds either by lath screens or by brush stuck firmly into the ground around the sides of the bed. Boards ten or twelve inches wide set on edge around the edge of the beds will furnish excellent protection from surface wind-sweep and consequent rapid drying out of the soil.

An excellent plan to follow in raising coniferous seedlings is to inclose the seed beds with twelve-inch boards placed on edge,

making the beds four feet wide and as long as desired. The soil within the bed should be one or two inches higher than that outside the frame. After the soil is carefully leveled and firmed with a piece of board the seeds are sown broadcast and covered to the proper depth by sprinkling fine soil upon them. Lath screens are then laid across the bed and allowed to rest upon the board frame. In this way trouble from strong winds, which might blow down the high screens, is avoided and moisture is readily retained. On cloudy days the screens should be removed, especially while the seedlings are young.

If an open place among trees and in partial shade is available the artificial screen may be omitted. Care should be taken to keep the surface of the soil comparatively dry, for a wet, soggy soil is almost certain to induce "damping off," a disease caused by certain fungi which thrive in poorly drained soils. A thin layer of pure sand spread over the surface of the soil is often used to check or prevent this trouble.

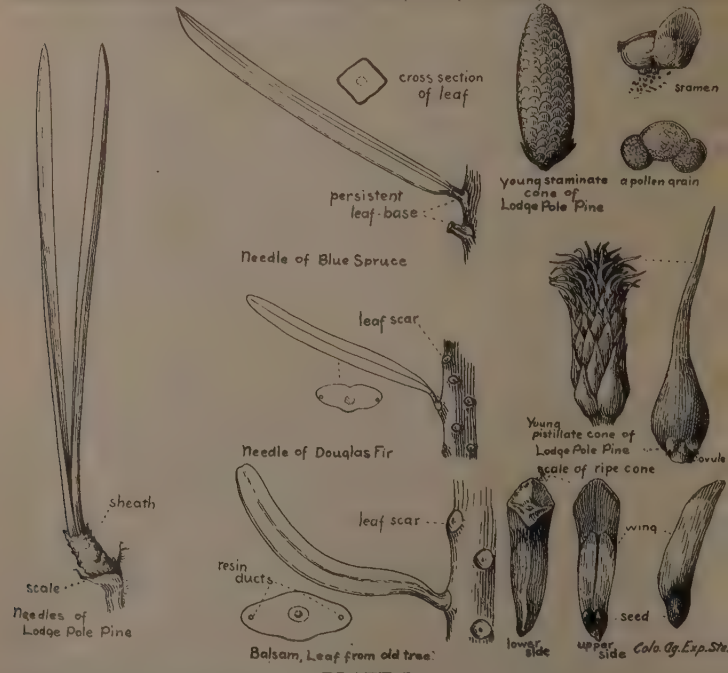

PLATE I.

Drawings showing leaf-characters that distinguish the pines, spruces and firs; also the flowers (young cones) of a pine, all somewhat enlarged.

On the approach of winter the bed of seedlings should be mulched with straw, leaves or evergreen boughs, which will protect the little trees from the injuries of alternate freezing and thawing. In the spring the mulch should be removed a little while before growth begins and careful cultivation with a fine toothed rake be given. At the age of two years the seedlings should be transplanted four to six inches apart in nursery rows as recommended for forest grown seedlings. They will in most cases be too small to transplant to permanent quarters until four years old.

SPECIES OF EVERGREEN TREES IN COLORADO.

The evergreen trees native to this state belong in two families —the pine family and the juniper family. The two families as they occur here may be distinguished by the following characters:

Pine Family.—Foliage leaves needle-shaped; single or in bundles of two to five; fruit a dry, scaly cone; seeds usually furnished with a thin wing.

Juniper Family.—Leaves awl-shaped or scale-shaped, in the latter case entirely covering the twigs; fruit berry-like, juicy or nearly dry; seeds usually without wings.

Of the thirteen evergreens occurring in Colorado which grow to the stature of trees ten belong in the pine family.

Pinaceae—PINE FAMILY.

(Plate I.)

KEY TO THE COLORADO GENERA.

I. Needles in tufts or bundles of two to five, mostly more than 25 m m. (1 in.) long, surrounded at base by a short sheath; cone scales thick, hard and woody when mature.

1. Genus Pinus.

II. Needles single, mostly less than 25 m m. (1 in.) long. Cone scales thin, leathery or papery when mature.

A. Needles in our species stiff and four angled, each one jointed to a short, hard, brownish base; branchlets rough from the prominent leaf bases which remain long after the upper part has fallen; cones pendulous, with persistent scales.

2. Genus Picea.

B. Needles flat, without hard, persistent bases, falling entirely away and leaving rounded scars; branchlets from which the leaves have fallen quite smooth.

a. Needles with a narrowed or stalk-like base, scars small, elliptical across the branchlets; cones pendulous, feathered with projecting, three-pointed bracts.

3. Genus Pseudotsuga.

b. Needles not narrowed at base, scars quite large, circular in outline; cones erect, dark purple or blackish, the scales falling separately from the axis.

4. Genus Abies.

GENUS *Pinus*—THE PINES.

The pines form the most important group of the cone-bearing trees. As indicated in the key they are most easily recognized by the needles being in bundles of two or more with a short sheath at the base. This sheath, together with the needles which it surrounds at the base, grows from a very short twig which arises just above a small, brownish scale that also represents a form of leaf. The staminate flowers occur in small cone-like clusters crowded around the stems at the base of the new growth of the season. After the blossoming, which occurs quite early in the growing season of the tree, the staminate flower clusters dry up and fall off and thus leave a bare space on the branch which bore them. The pistillate or seed-bearing cones appear near the tips or along the sides of the new growth. At first they are small and are usually overlooked. After the blossoming period they develop rather slowly and do not mature their seeds until the second autumn. The scales of the cone are thick and hard and in some species each is furnished with a sharp curved prickle. Two seeds are borne at the base of each scale. As the seed matures a part of the scale peels off wtih the seed and forms its wing.

KEY TO THE COLORADO SPECIES OF PINUS.

I. Needles, five in a bundle.
  a. Scales of the cone tipped with curved prickles.
    1. Pinus aristata.
  b. Scales of the cone without prickles.
    2. Pinus flexilis.

II. Needles two to three in a bundle.
  A. Needles 8-12.5 c. m. (3-5 in.) long.
    3. Pinus scopulorum.
  B. Needles not over 6 c. m. (2⅜ in.) long.
    a. Needles 3-6 c. m. (1¼-2⅜ in.) long; seeds small, 4-5 m m. (5/16 in.) long.
      4. Pinus Murrayana.
    b. Needles 2-4 c. m. (¾-1½ in.) long; seeds large, 10-15 m m. (⅜-⅝ in.) long.
      5. Pinus edulis,

FOXTAIL PINE, HICKORY PINE.

(*Pinus aristata,* Engelm.)

(Plate II B)

The foxtail pine occurs chiefly in the higher altitudes among the mountains of central and southern Colorado, in Utah, Nevada and southern California and Arizona. It is a small or medium sized tree of bushy habit, seldom reaching a height of 12-15m. The short needles grow in bundles of five closely crowded along

PLATE II.

A. Flowers or young cones of lodge pole pine.
1. Staminate flower-clusters.
2. Pistillate cones on new growth.

B. Branch and cone of Foxtail pine.

the branchlets in brush-like tufts. The cones are about 8 cm. long and each scale is furnished at the tip with a slender curved bristle. On the branches of young trees the bark is at first smooth and milky white. On trunks of older trees the bark becomes irregularly divided into small scales of a brownish color. The wood is soft and light and possesses but little strength. It is sometimes used for mine timbers and fuel.

This tree is of but little commercial importance and its slow growth does not recommend it for planting where quick effects are desired.

LIMBER PINE, ROCKY MOUNTAIN OR WESTERN WHITE PINE.

(*Pinus flexilis*, James; *Apinus flexilis*. Colo, Exp. Station Bulletin 100, Rydberg.)

(Plate III.)

The common name of this pine is suggested by the long, lateral branches which are quite stout and enable this tree to survive in the wind-swept situations which it usually inhabits. It is of low topped form and stout trunk and occurs often at high altitudes in rocky, exposed places. The needles grow in bundles of five and are about 5 cm. long. At a little distance this tree resembles the foxtail pine, but is readily distinguishable from the latter species by the cones. Those of the limber pine are composed of numerous rather thin scales entirely free from prickles. The seeds are large and approach in size those of the pinion pine. In fact, this pine is not infrequently mistaken for the true pinon. It is readily distinguished by the fact that the needles of the pinon are in bundles of two instead of five as in this species.

The bark of the young branches and stems is smooth, light gray or white, becoming deeply fissured and dark brown or nearly black on old trunks. The light, soft wood is sometimes used for lumber, but is sure to be full of knots.

The limber pine is quite widely distributed, occurring along the eastern slope of the Rockies from Alberta to western Texas and southern California. Its largest size, occasionally 15-20 m. high, is reached in northern New Mexico and Arizona. In Colorado this pine is scattered throughout the higher portions of the mountains.

The limber pine is adapted to planting as an ornamental tree where large size is not desired.

Its hardy character enables it to thrive under cultivation and when thus grown it forms a tree of compact form and pleasing appearance. It is worthy of a place in the home grounds.

BULL PINE, ROCKY MOUNTAIN OR WESTERN YELLOW PINE, ROCK PINE.

(*Pinus scopulorum* (Engelm.) Lemmon)

(Plate IV.)

This is the largest of our pines and forms the prinicpal evergreen of the foothills and ridges along the mountain ranges and in the mountain parks. Outside this state it occurs in western Nebraska and from Montana to Arizona and New Mexico. On the Colorado plateau this tree forms the most extensive pine forests on the continent. From northwestern Nebraska

PLATE III.

Needles, cone and tree of Limber pine.

PLATE IV.
Trunk, cone and needles of Bull pine.

and western Texas to the Pacific Ocean and from southern British Columbia to southern California and Mexico this pine is replaced by the species pinus ponderosa, of which it is often considered as the variety scopulorum.

In Colorado the bull or rock pine forms rather open woods or forests on the slopes of valleys. Here it grows to a height of 24-30 m. (80-100 ft.) high and 1 m. (40 in.) in diameter. On the exposed rocky ridges and slopes it forms a spreading tree of stocky growth. The dark green needles are in bundles of two to three and vary in length from three to six inches. The cones are two to three inches long and the scales are tipped with stout recurved prickles, which on old cones are often missing. On large limbs and trunks the bark is blackish or cinnamon colored and on old trunks becomes thick and deeply furrowed. The wood is heavy and strong, but differs much in quality and is apt to be quite knotty. Its main uses are for lumber, railway ties and mine timbers.

This pine, on account of its deep growing root system, is able to resist drought better than almost any other of our evergreens. Thus it is well adapted to planting on the semi-arid plains and in dry, exposed situations. Under cultivation it is capable of rapid growth in diameter. A tree on the Agricultural College campus has averaged nearly one inch increase in diameter for each two years, the diameter when cut being seven inches at breast height, and with fifteen annual rings of growth. This rate of growth suggests this as a suitable pine for the tree plantation. When planted for lumber the trees may be planted twelve feet apart each way and the lower limbs be pruned off to form clean trunks as the trees grow in height.

This pine is quite easily grown from seeds, which are of good size, and which germinate readily.

(See directions for growing evergreens from seed).

The seedlings do not require shading when young as in the case of most evergreens. They should be transplanted when one or two years old to increase the number of fibrous roots. When four years old they may be set in permanent quarters if growth has been good.

LODGE POLE PINE, BLACK PINE.

(*Pinus Murrayana,* Oreg. Com.)

(Plate V. a. c.)

The lodge pole pine, so named from the use which the Indians once made of it in building their lodges, is a common evergreen in the hills and mountains of the northwestern states. It usually prefers northern slopes, which it covers with a dense growth. The trees are tall and straight and carry most of the foliage toward the top, especially when growing in forests. At a distance masses of this tree are noticeable on account of the yellow green of the foliage. It usually reaches higher altitudes than the rock pine. The needles are in bundles of two and are about two inches in length. The cones nearly equal the leaves in length and are composed of thick, hard scales, each of which is tipped with a slender prickle. The cones often remain closed and attached to the limbs sometimes for many years so that they occasionally become entirely overgrown by the enlarging stem.

A strong heat will cause the cones to open and allow the seeds to fall out. As the seeds may retain their vitality in the closed cones, sometimes for twenty years, a quick forest fire often brings about a reseeding of the burned district where this tree grew, by causing these old, "tight" cones to open.

The wood of the lodge pole pine is soft, light, and lacks durability. It is used to some extent for lumber, railway ties, mine timbers and fuel. The wood, when properly seasoned and treated with preservatives, is greatly improved in durability.

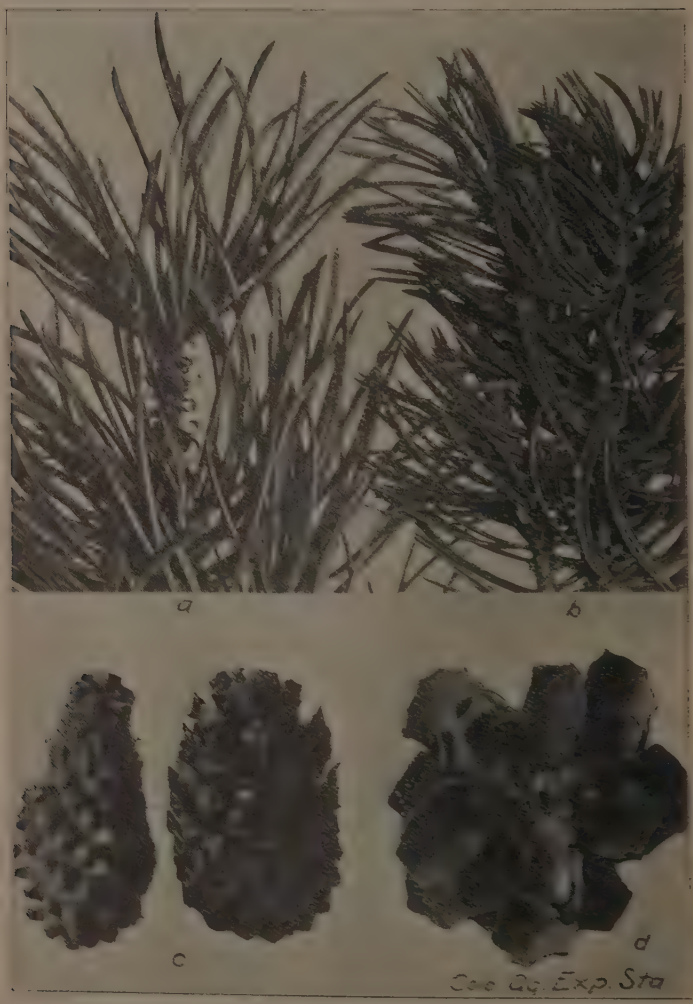

PLATE V.

a, c. Needles and cones of Lodge pole pine.
b, d. Needles and cone of Pinon pine.

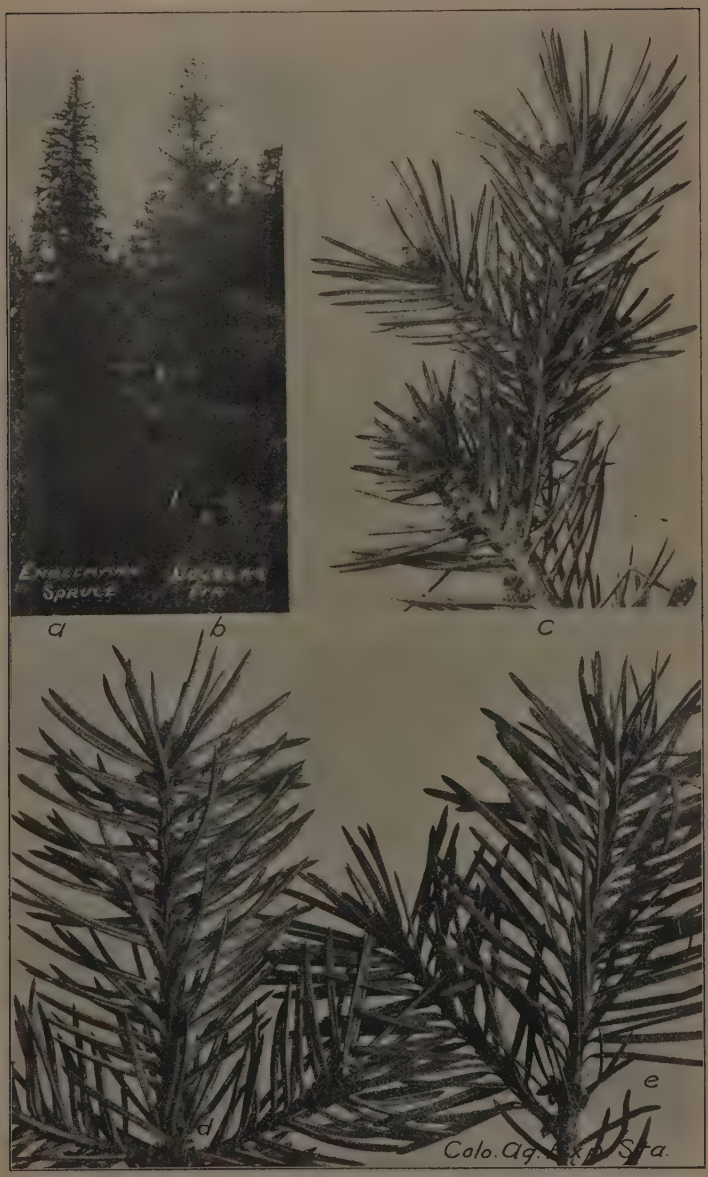

PLATE VI.

a. c. Engelmann spruce tree and foliage.
b. e. Douglass fir tree and foliage.
d. Foliage of Blue spruce.

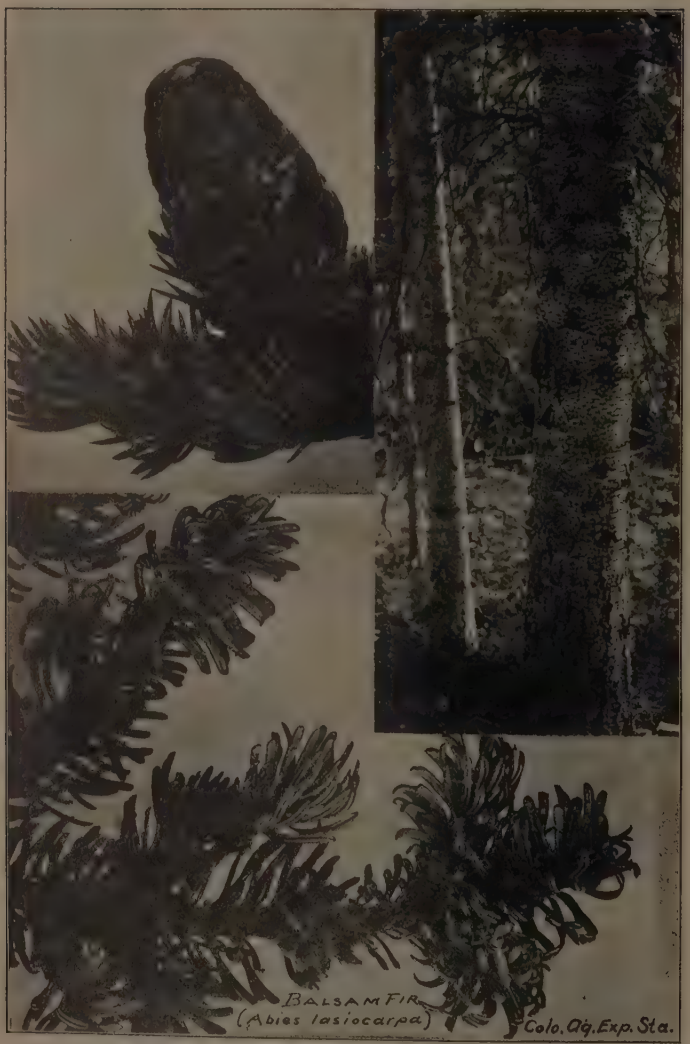

PLATE VII.

Immature cone, foliage and trunk of Balsam fir (Abies lasiocarpa)

PLATE VIII.

Group of Colorado Blue spruce.
1. Branch showing scale-like leaves and berries of Rocky Mountain Red cedar (natural size).
2. Branch showing awl-shaped leaves and berries of low Juniper, (natural size).

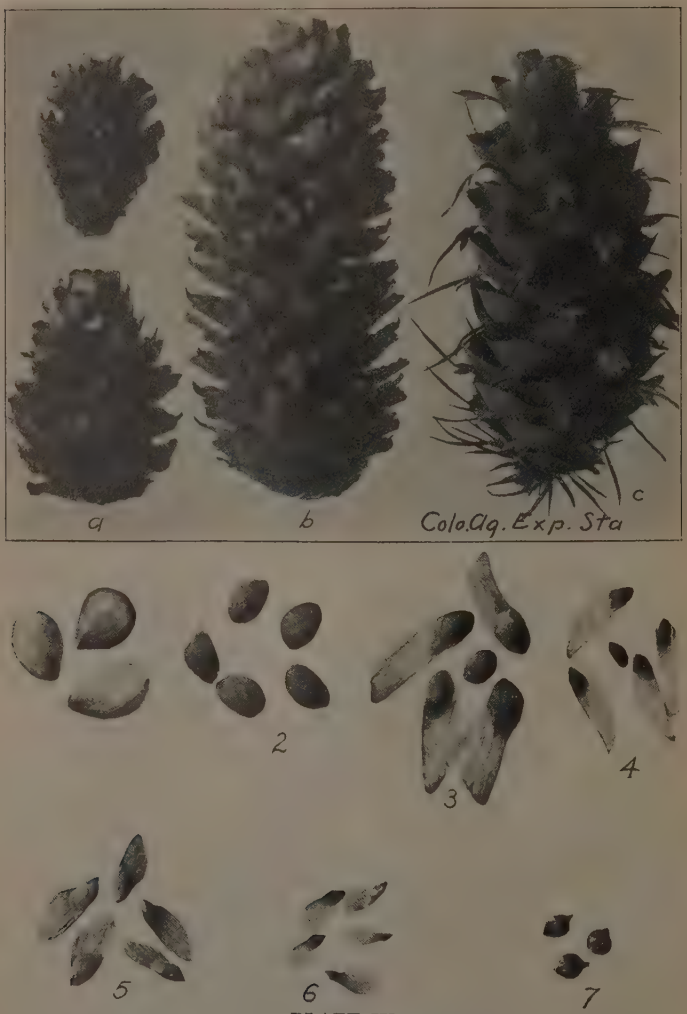

PLATE IX.

a. Cones of Engleman spruce.
b. Cone of Blue spruce.
c. Cone of Douglass fir.
1. Seeds of Pinon pine.
2. Seeds of Limber pine.
3. Seeds of Bull pine.
4. Seeds of Lodge Pole Pine.
5. Seeds of Douglass fir.
6. Seeds of Blue spruce.
7. Seeds of Red cedar.

(all natural size)

The lodge pole pine is capable of making a rapid growth under favorable conditions. It prefers a moist soil and may be used in the wind-break where such conditions prevail. When well established, however, it is hardy and enduring.

PINON, NUT PINE.

(*Pinus Edulis* (Engelm.) *Caryopitys Edulis* Colo. Bulletin 100.)

(Plate V. b. d.)

This is the pine from which the pinon nuts sold by fruit venders in cities are obtained. The tree is of small or medium size, with compact, pyramidal or rounded head. It occurs scattered or in open forests among the eastern and western foothills of Colorado, in southwestern Wyoming and western Texas and Arizona. It is not a tree of the high altitudes. The short, stiff leaves are in bundles of two and about one inch in length. The short, broad cones equal the leaves in length and are composed of few scales. The seeds are the largest of those of any other pine in this region. They are about the size of field beans and are wingless when separated from the scales of the cones.

This tree is useful mainly for its edible seeds, although the wood is sometimes made into lumber. It is quite extensively used for fuel and the manufacture of charcoal.

The pinon pine is adapted to growing in dry situations and for this reason may be planted where moisture is lacking. Its low, stocky growth adapts it for planting where a low mass of evergreen foliage is desired. The seeds germinate readily and this tree may be quite readily grown in this way. The seedlings may be transplanted at two years of age to encourage a compact root development.

GENUS *Picea*—THE SPRUCES.

The spruces are tall growing trees with conical or pyramidal form and tapering trunks. The needles are single, which distinguishes these trees from the pines, four angled and sharp tipped. At the base a short stalk-like portion is jointed to the green part of the needle and remains on the branchlet after the upper part of the needle has fallen. This makes the branchlets from which the leaves have fallen very rough and readily serves to distinguish the spruces from the firs.

The bark of the older limbs and trunks is usually dark grayish or reddish brown and consists of thin scales. The cones are hanging or pendulous when ripening and occur in the uppermost parts of the tree. They consist of thin scales each bearing two winged seeds. The seeds mature in the autumn of the first year. They are mostly small, pointed at the base and furnished with long, thin wings.

The spruces furnish some of our most ornamental evergreen trees, besides which they are useful in forming hedges, windbreaks and shelter belts.

KEY TO THE COLORADO SPECIES OF *Picea*.

A. Needles very stiff and sharp pointed, surface of twigs among the needles entirely glabrous or free from hairyness; cones 5-7.5 c. m. (2-3 in.) long.

1. Picea Parryana.

B. Needles less rigid and sharply pointed, surface of the twigs among the needles finely pubescent or hairy; cones about 4 c. m. (1⅝ in.) long.

2. Picea Engelmanni.

BLUE SPRUCE, COLORADO BLUE SPRUCE, SILVER SPRUCE.

(*Picea Parryana* (Andree) Sarg.)

(Plates VI. d., VIII., IX. b.)

This is one of the most admired and widely known evergreens and is certainly the handsomest of the spruces when well grown. It is somewhat limited in range, being found in Colorado and eastern Utah and northward into Wyoming. It commonly grows in small groups or groves along the streams in the mountain valleys and parks. It usually reaches a height of seventy-five to one hundred feet, occasionally taller, with a trunk one to two feet in diameter. The leaves vary in color from bright green to silvery greenish blue—the new growth being more distinctly bluish or silvery than the older foliage. Young trees are often very symmetrical and beautiful. When old the tree may become somewhat ragged and open and the color of the foliage may lose a degree of its blueness.

The bark is broken into rather small, oblong scales and on old trunks becomes thick and furrowed or grooved lengthwise. This character helps to distinguish the blue from the Engelmann spruce, the latter having the bark broken into rounded plate-like scales even on old trunks.

The cones consist of numerous thin scales narrowed toward the tips. They are usually prominent objects, as they hang in clusters in the upper part of the tree.

The wood is soft, light and weak and is sometimes used for lumber and fuel.

The blue spruce is largely planted for oranment and when well grown forms most beautiful specimen trees. For this purpose the bluest specimens are selected by the nurserymen, as the price which they bring is high in proportion to the blueness. This tree is well adapted to the formation of hedges and when well tended may be made impassible even to the smaller animals.

The blue spruce may be grown from seeds, gathered preferably from the bluest specimens, or native seedlings may be dug from the mountains where they occur. If wanted for specimen trees only the bluest should be saved, although the greener plants are equally useful for hedges and windbreaks. The finest specimens are usually obtainable through reliable nurserymen who grow them in large numbers, the best ones being propagated by grafting.

The blue spruce is at its best only when grown in a moist soil and under conditions of cultivation. When clothed in the new growth of the season such trees have the appearance of being frosted with pale blue, at which season they are unexcelled in beauty among trees.

THE ENGELMAN SPRUCE.

(*Picea Engelmanni* (Parry) Engelm.)

(Plates VI. a. c., IX. a.)

The Engelmann spruce is frequently confused with the blue spruce, which it often greatly resembles. It is a much larger tree than the blue spruce, in its northern range often growing to a height of 150 feet with a trunk four to five feet in diameter. Old trees are apt to be less regular in form than the blue spruce and the color is seldom so blue as the latter. The needles are less rigid and sharp than those of the blue spruce, so that an experienced nurseryman can usually distinguish the two by grasping the foliage with the bare hand. The leaves, furthermore, possess a disagreeable odor when bruised.

The surface of young twigs, under a hand lens, appears fuzzy or short hairy. This can be distinguished even by the naked eye if the twig is held up so that its outline is seen against the sky. The bark of large trunks is seldom grooved or furrowed as in the blue spruce, but is broken into rounded, plate-like scales of a reddish brown color.

The cones of the Engelmann spruce are seldom over one and a half inches long and the scales are often more rounded than those of the blue spruce.

The Engelmann spruce reaches the highest levels of tree growth and at timber line forms distorted spreading mats of scrubby growth. It is the most abundant of spruces in Colorado and forms extensive forests on the upper slopes and along the mountain streams. In its range it extends in general southward from the mountains of British Columbia through the interior mountain ranges of the continent to northern New Mexico and Arizona. It reaches its greatest beauty and size north of the United States boundary.

The bark is sometimes used for tanning leather. The wood is light and soft and is extensively manufactured into lumber, railway ties and to some extent is used for poles. It is probably our most valuable timber tree. The Engelmann spruce is not often planted for ornament, but is well adapted to such use in this state.

GENUS *Pseudotsuga*—DOUGLASS SPRUCE.

The members of this genus are tall, stately evergreens with much the same form as the spruces. They are nearly intermediate in some characters between the true spruces and the firs. The needles are single on the branchlets and are contracted at the base into a short stalk. They are soft, flattened, blunt at the tips and possess a prominent midrib in the form of a narrow ridge on the lower side. When the needles fall they leave small rounded scars on slightly raised portions of the branch. In these respects the Douglass spruces resemble the true firs. The cones, however, are in most respects like those of the spruces in that they are pendulous or hanging and that they remain entire when mature. The cones are readily recognized from those of the spruces, as well as other members of the pine family, by their feathered appearance, due to the presence of slender-toothed bracts that project from between the scales. This character is so prominent that these trees can be recognized as far as the details of the cones are visible.

Only two species in this genus are known in North America, one of which occurs in Colorado.

DOUGLASS SPRUCE, DOUGLASS FIR, RED FIR.

(*Pseudotsuga mucronata* (Raf.) Sudw.)

(Plates VI. b. e., IX. c., 5.)

The Douglass spruce is known by a number of common names throughout its range. It occurs among the hills and mountains of the greater portion of the Northwest, extending from British Columbia and Alberta on the north to northern Mexico and Texas on the south. It is a tree of conical form when young. It reaches its greatest size in the moist climate near the coast of Washington and Oregon and in the western foothills of the Cascade mountains, where it reaches a height of 200 feet or more with a trunk sometimes 10 to 12 feet in diameter. In the drier inland regions it is usually less

than one hundred feet tall and two or three feet through. The bark remains comparatively thin and smooth for a number of years, but on old trunks becomes thick and deeply cracked and furrowed into gray, coarsely broken ridges. The wood is light red or yellowish in color and variable in density and quality. It is largely manufactured into lumber in its northwestern range, and is extensively employed in construction work, railway ties, piles, and for fuel. Two varieties of this tree, the red and the yellow fir, are distinguished by lumbermen. The former of these is coarse grained and dark colored and is not considered so valuable as the latter. The bark is occasionally used in tanning.

The Douglass spruce is planted quite extensively as an ornamental tree in the eastern United States, and numerous forms or varieties are in cultivation. It is a tree of rapid growth, especially when planted in a moist soil. It has not made as healthy a growth on the Agricultural College grounds at this station as the blue spruce. It is readily grown from seeds, which are of fair size. This evergreen may be recommended for planting in the windbreak and for specimen trees on the lawn.

GENUS *Abies*—THE FIRS, BALSAMS.

The firs are tall growing, conical trees quite similar in appearance to the spruces. They are fond of the higher altitudes where the cold air and the moisture of frequent storms bring them to their greatest perfection. The leaves, like those of the spruces, are simple and grow from all sides of the branchlets. Those on the lower sides of the twigs, however, turn upward in such a way as to form flattened masses of foliage. The branches arise in whorls from the sides of the main trunk so that when viewed from the side such trees appear in the form of circular terraces of foliage disposed with beautiful regularity.

The needles are flattened, usually grooved above and slightly notched at the tip. The cones occur only in the topmost parts of the trees and stand erect on the upper side of the branches. They are mostly purplish or blackish in color, with thin, closely crowded scales. When mature the cones break up by the falling away of the scales, so that complete cones of the firs are never found beneath the tree.

The bark on young trees is smooth, but becomes roughened and broken on old trunks. The wood is mostly soft and brittle and is not prized by the lumbermen.

The name Balsam, which is often applied to the trees of this genus, is suggested by the presence of balsam or resin vesicles in the bark.

The balsam fir of the northeastern states and Canada *(Abies balsamea)* possesses balsam-containing blisters in the bark from which the substance known in commerce as "Canada Balsam" is obtained.

KEY TO THE COLORADO SPECIES OF *Abies*.

A. Leaves of vigorous lower branches 2.5-4.5 c. m. (1-1¾ in.) long; the two resin tubes, as seen in cross section under hand lens, deeply imbedded within the leaf tissue. Cones purple or nearly black.

1. Abies lasiocarpa.

B. Leaves of vigorous lower branches 4.5-7.5 c. m. (1¾-3 in.) long. The two resin tubes close to the lower surface. Cones green, yellow or purple.

2. Abies concolor.

BALSAM FIR, ALPINE FIR.

(*Abies lasiocarpa.* Nutt.)

(Plate VII.)

This tree is distributed throughout the mountainous parts of western North America. In Colorado it frequents the high mountain slopes and summits. It is a medium sized tree seldom over 100 feet tall, in this state, and two feet in diameter.

The leaves on the cone-bearing branches are usually short, stiff, and curved upward and tipped with sharp points. The cones are frequently almost black in color and are usually smeared with pitch. The bark on young trunks is quite smooth with numerous transverse scars, but on old trunks becomes cracked and scaly.

The wood of this tree is considered of little value by the lumbermen, as it lacks strength and durability and is adapted only for the coarsest quality of lumber. It is used for fuel to some extent. The writer found, in the cutting of timber from one forest reserve, that this fir was being removed to make room for the more valuable Engelmann spruce with which it was growing. This fir is planted to some extent as an ornamental tree in the northern United States and Europe.

WHITE FIR.

(*Abies concolor,* Lindl.)

The white fir, with its regular whorls of frond-like foliage masses, is a very handsome tree. During the first year or two the leaves are similar in color to those of a good specimen of the silver spruce, which it often rivals in beauty. It is a much larger tree when fully grown than the preceding species. It is the only fir within the arid regions of the Great Basin and of southern New Mexico and Arizona. In Colorado the white fir is found only in the southern half of the state extending to the Pike's Peak region. Some handsome specimens of moderate size are to be seen in North Cheyenne Canon, near Colorado Springs. The leaves are considerably longer than those of the balsam fir and the cones are larger and usually lighter in color. The wood, while coarse grained and not strong nor durable, is sometimes used for lumber of which packing cases are made. The tree is planted to some extent for ornament and is worthy a trial, as well grown specimens are pleasing in form and color and may serve to introduce variety in the evergreen plantings in parks and about the house.

Juniperaceae—JUNIPER FAMILY.

The members of the juniper family are distinguished from those of the pine family principally by the fruit. Thus, instead of forming a dry cone composed of woody or parchment-like scales, the junipers possess a berry-like fruit, in the pulp of which the seeds are imbedded. These berries, however, were at first much like the very young cones of the pine family. The scales of which they are composed are enlarged at the outer end and are comparatively few in number. After the ovules are fertilized by pollen from the staminate flowers, which in the junipers occur on distinct trees, the scales grow together and form the so-called juniper

berry. On close examination, marks indicating where the scales were located can be easily seen.

The seeds of the junipers are furnished with hard, bony coatings which enable them to pass unharmed through the alimentary canal of birds, which sometimes feed upon them, and in this way distribute them to new locations.

The junipers are strongly aromatic and from some species volatile oils are obtained which are used in medicine and in the manufacture of perfumes.

The wood of the juniper is close grained, not hard, but durable. Most of the species of junipers which occur in this state are low, spreading, shrubby plants which are not adapted to the production of lumber. These low-growing sorts, however, are well suited for planting in the shrubbery border, on exposed banks and to cover the tops of walled terraces and rockwork.

Two genera of the juniper family are represented in Colorado, but only three species commonly reach the stature of small trees.

KEY TO THE COLORADO GENERA OF THE JUNIPER FAMILY.

A. Leaves in whorls of three, on mature branches, awl-shaped, spreading, 10-12 m m. (⅜-½ in.) long, channelled and whitened above, convex and green below. Buds scaly.

Genus Juniperus.

B. Leaves opposite in pairs, on mature branches, scale-like and flattened against the branchlets to which they are usually grown fast; about 2-3 m m. (⅛ in.) long. On young trees and vigorous shoots the leaves are usually longer, slenderly pointed and somewhat spreading. Buds naked.

Genus Sabina.

GENUS *Juniperus*—THE JUNIPERS.

(Plate VIII. 2.)

The species of junipers which occur in Colorado frequent the rocky hills and exposed mountain slopes. They are distinguished from the red cedars or savins principally by the leaves being comparatively long and joined to the branch much like those of the spruces. The berry-like fruit of the junipers is borne close against the side of the branch, while that of the red cedar is on the end of a very short branch.

Two species of the genus are known in this state. The first of these, the mountain or low juniper *(Juniperus sibirica)* (Plate VIII. 2) is a low spreading shrub common in the foothills and rocky places in the mountains. Its leaves are abruptly bent at the base and are deeply grooved on the upper surface.

This shrub is worthy a place in the shrubbery border and from

its hardy, drought-resisting character may be used where moisture is not plentiful

The common juniper *(Juniperus communis)* sometimes reaches a considerable size, especially in its eastern range. In its low form it is scarcely distinguishable from the former species, but is apt to be more erect and with straight, nearly flat leaves with tapering points.

The distilled liquor commonly known as gin owes its flavor to the use of juniper berries in its manufacture.

The common juniper is adapted to forming low hedges, as it endures clipping well.

GENUS *Sabina*—RED CEDARS, SAVINS, JUNIPERS.

(Plate VIII. 1.)

The common red cedar is the type of tree of the present genus. The foliage consists usually of two somewhat distinct forms of leaves. Those on the main branchlets are frequently one-fourth to three-eighths inches long on vigorously growing trees, with the pointed tips free and somewhat spreading. On the smaller lateral branchlets the leaves are usually less than one-eighth inch in length, are scale-shaped and broadly pointed. Both forms of leaves adhere closely to the branchlets on which they grow so that the younger stems are entirely covered by the leaves. After one or two years the longer leaves die and turn brown, but do not entirely disappear until the branch is several years older.

The oldest leaves are shed in spring of each year at the beginning of the growing season, but instead of falling singly as in the junipers, the small lateral branchlets drop off, carrying with them the closely adhering scale-leaves.

The heart wood of the red cedars is soft but fine grained and very durable and possesses a pleasing fragrance which is retained almost indefinitely. The wood has been extensively employed in the manufacture of water pails and wooden ware, for interior finish and for cabinets and chests for protecting furs and woolens against the ravages of moths. It is the principal wood used in the manufacture of lead pencils and is probably the only wood sold by the pound. The rapidly diminishing supply for this purpose is being felt by the manufacturers of pencils, who are beginning to consider possible substitutes.

The oil of red cedar, distilled from the leaves and wood, is used to some extent as a perfume, as it imparts the characteristic odor of the wood to cheaper woods.

The berries ripen in the autumn of the season they were produced.

Of the four species of red cedars known in Colorado three are sometimes trees of small or medium size. The characters which separate them are not easily recognized except by botanists.

The Utah red cedar (Sabina utahensis) is a bushy tree seldom more than twenty feet high, which occurs in the desert region between the Rocky and Sierra Nevada Mountains. It is found in the western parts of this state on dry mountain slopes and tablelands. It is locally used for fuel and fencing and the fruit, which is a rather dry, sweet berry, is used for food by the Indians, either fresh or ground and baked into cakes.

The single-seeded red cedar (Sabina monosperma) occasionally reaches a stature of forty to fifty feet in favorable locations. It occurs along the eastern base of the Rocky Mountains in the southern half of Colorado and extends to western Texas, over the mountain ranges of Nevada and into Mexico. It is often associated in southern Colorado and Utah with the pinon pine.

It is usually an irregular, open-headed tree, with red-brown bark on the naked branchlets and thin, grayish, scaly or shreddy bark on the trunks. The fruit is about one-eighth to one-fourth inch long, black with a whitish bloom and contains usually one or rarely two or three grooved seeds. The wood and fruit of this species are used for the same purposes as in the preceding species.

The Rocky Mountain Red Cedar (Sabina scopulorum) (Plate VIII 1.) is widely distributed throughout the northwestern portions of the United States, from the eastern foothills of the Rocky Mountains to the coast of British Columbia and Washington, and from Alberta to western Texas and northern Arizona. It frequents the foothills and river bluffs and is our common red cedar in most parts of Colorado. It reaches a height of thirty to forty feet, when favorably situated, and forms an irregular round topped head.

The berries are bluish black with a bloom and contain one or two bony-shelled, grooved seeds. The fruit is usually somewhat larger than that of the preceding species and ripens at the end of the second season.

The red cedars, on account of their very fine foliage and branchlets, may be effectively used among other evergreens to give variety to the planting. Their foliage is usually somewhat grayish in winter. Although of slow growth their hardiness and the fact that they bear pruning well fits the red cedars for use in forming hedges and windbreaks.

Bulletin 131 July, 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Arsenical Poisoning of Fruit Trees

BY

WM. P. HEADDEN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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ARSENICAL POISONING OF FRUIT TREES.

WM. P. HEADDEN.

I was called upon at one time to investigate the cause of the death of some shade and ornamental trees, and the bad condition of the property in general. The claim was advanced that arsenic and lead were the cause, more particularly the former. The assertion was made that animals had died as the result of feeding upon the grass growing on the premises. Examination of the grass, the bark of the trees, the soil, and the dust which had collected in unused portions of the buildings, all showed an abundance of arsenic, lead and copper.

In connection with the preceding facts, the probable cause of the death of the trees seemed apparent and yet certain considerations led me to be cautious in insisting upon the arsenic present as the cause. For instance, calcic arsenite was at that time being used on our fruit trees to destroy the codling moth—the whole tree from the outermost twigs to the very base of the trunk was, I well knew, literally bathed with this arsenical preparation several times in the course of a season. The whole of this arsenic sooner or later found its way to the soil. I had not, at that time, proved by direct experiment, nor learned that any one claimed that the fruit trees had been injured by this arsenic. This seemed to me so strong an argument against the too ready assumption that arsenic was really the cause of the death of the trees, that I felt obligated to caution the attorneys that it was not clear to my mind, that neglect had not contributed more to the condition of the property than the causes complained of. Still the facts were well established, i. e., the trees were dead and arsenic was present, also lead and copper, and in spite of the fact that our apple and pear trees were being sprayed, a number of times annually with arsenical preparations and no injury reported, except in cases where the arsenic had been applied in a soluble form, I was quite fully convinced, that the arsenic had contributed largely to the death of the vegetation on this property.

The protection against arsenical poisoning in the case of our orchard trees is the insolubility of the arsenical preparations used in spraying and further that these preparations shall not be changed or become soluble in the soil. In the case referred to, it would have been judged that the iron and especially the lime present, both as carbonate and sulfate, was sufficient not only to render the arsenic insoluble but also to prevent its being brought into solution again, still it was my opinion that the arsenic was really the principal cause in the destruction of the vegetation in question.

While the conditions met with in the case of this property were not identical with those existing in orchard culture, they had enough in common with them to convince me that there were but two conclusions to draw, either that I was in error in regard to the agency of the arsenic in this case, or that there would come a time and that soon, when the arsenic applied would eventually find its way into the soil and prove a source of danger to the trees. I was, at that time, going on four years ago, so fully convinced that the arsenic would become a source of grave danger, that I ventured to express this view to the orchardists of the State and cautioned them that the probability of injury from this cause was imminent.

Prof. Gillette, who as an Entomologist, is interested in the control of insects injurious to the fruit crops of the State, has repeatedly suggested that I should take up this line of investigation. Prof. Paddock, also who, as a Horticulturist, is interested in the diseases of the trees—has made the same suggestion. These statements are not made to devolve any responsibility upon these professors but to show that this view has not been hidden from the people or my colleagues and the presentation of this bulletin is not a hasty resolve or a thing done without a very keen appreciation of its importance not only to the orchardists of Colorado but to all orchardists.

I will add before leaving these introductory paragraphs, that this work in my Department is directly an outgrowth of my attempt to study the alkalies of this State, but I deem it both just to the interests of the State and wise to segregate it, and present it at the earliest advisable time, irrespective of the rest of the work.

It will appear in the proper place how the injuries herein described and explained are influenced by the alkali, indeed, the orchardists themselves have repeatedly suggested this by such questions as: Has our strongly alkali water any effect on our spray material, specifically upon the lead arsenate?

While the suggestions of danger were made so long as three years ago, no observations of any trouble were officially made public until January 1901, when Mr. O. B. Whipple in his report as Field Horticulturist of the Western Slope Fruit Investigations calls attention to certain difficulties under the title of Root Rot. I give the whole of his report touching upon this subject taken from Bulletin 118 of this Station:

ROOT ROTS.

"Two apparently distinct forms of root rot are found. One form which is proving the least destructive of the two, seems to show no preference for varieties, and confines itself to that part of the tree below the ground. The other seems to work exclusively on the Ben Davis and Gano and the trunk as well as the roots are affected. The disease often extends upward into the large branches. The first indication of the disease is the appearance on the trunk of spots of a chocolate color. When peeled off the bark has a peculiar marbled appearance, the diseased portions standing o

in sharp contrast to the healthy tissue. The disease soon kills the bark and it dries down to the wood, taking on a dark brown color. Two seasons are required for the disease to kill the trees. The first season the trunk is girdled and the foliage drops early. This early ripening of the foliage is often the most prominent symptom and diseased trees can be easily picked out in the early fall. (See Plate I., lower figure). Trees showing an early bronzing of the foliage are generally found girdled by this disease. The second season the tree starts into leaf as the normal tree, generally setting fruit, and dies in mid-summer, the fruit and leaves clinging. (See Plate I., upper figure). The disease seems to be infectious, as the trees appear in groups, and in many cases it appears as though it were carried by water. When a diseased tree is found, several more are generally found in the same row. However, other varieties besides the Ben Davis and Gano may stand in the same row with diseased trees on either side and show no sign of contracting the disease. The fact that Ben Davis and Gano are very tender as regards the application of arsenical sprays has suggested to my mind that the trouble may be due to arsenic collecting about the crown of the tree and killing the bark. However, the fact that trees sprayed with arsenate of lead and arsenite of lime are alike affected, seems to be contrary to such a hypothesis.

"Prompt removal of the trees affected seems at present to be the only treatment that can be suggested. Reports indicate that the disease has only been in the orchards two or three years at the most. Soil conditions seem to have no relation to the disease, as it is found on all kinds of soils."

The description of the affected trees as given by Mr. Whipple is, I believe, entirely reliable as he has been in this field for several years, and has had opportunity to observe these trees at all stages of the affection. I can, in fact, corroborate his statements as Mr. Whipple was kind enough last Autumn and again this spring to point out a number of these trees at different stages in the process of dying. While the appearance of brown spots on the trunk of the tree are observable early in the progress of this trouble, they are not the seat of the trouble, which beginning on the crown of the tree has by this time advanced to the trunk. Whether it ever begins on the roots below the crown is not at present known. It is not to be wondered at that Mr. Whipple, without a definite knowledge of the cause of the trouble, states that the disease seems to be infectious. He pointed out to me a row of Ben Davis trees, four of which were already dead, with leaves and fruit still clinging to them. In the adjoining row was another tree which was likewise dying, as I now recall it—this tree stood at a point where the irrrigation water crossed from the row of four dead Ben Davis trees and passed close to this one, seemingly justifying Mr. Whipple's inference that the disease is infectious and also the further statement, "and in many cases it appears as though it were carried by water." My explanation of this is a different one as will appear in a future paragraph.

Mr. Whipple in the next sentence, calls attention to an important fact, i. e.—that the two varieties, Ben Davis and Gano, are very sensitive to arsenical sprays, and suggests the possibility that the trouble may be due to arsenical poisoning, but seems to dismiss this as an untenable hypothesis. Another point in Mr.

Whipple's very brief account of this disease is that the disease had been noticed for only two or three years. Information which he and I have since gathered corroborates this statement; the earliest observation of the affection of the trees of which we were able to learn was in 1904 and trees have been dying in certain orchards annually since that date.

VARIETIES AFFECTED.

The varieties affected in this way are by no means confined to the Ben Davis and Gano. The following varieties are also affected: Spitzenberg, Early Harvest, Wolf River, Lawver, Blacktwig, Baldwin, Jonathan, Grimes Golden, and Pewaukee, and without doubt, other varieties might be added if search were made to find every variety affected in this way. The trouble also extends to pear trees, but I have studied apple trees mostly.

AREA INVOLVED.

At this writing I am not prepared to give any territorial limits to the trouble. I have observed it from near Fruita almost to Palisade and in the neighborhood of Delta. I am further credibly informed that the same condition of the trees has been met with in the neighborhood of Canon City. If this latter statement is correct, our principal orchard growing sections are involved and the importance of definitely establishing the cause and if possible, a correction for the trouble, becomes very great.

THE NUMBER OF TREES AFFECTED.

This would be very difficult to determine and I have no data on which to base even a rough estimate, but an idea may be obtained from the following facts. One man stated that in the last few years, he had lost 50 per cent of his Ben Davis. Another stated that he began pulling up a few trees four years ago and this year he had removed nine trees and there were others which he should have removed; another man had removed twelve and still another the same number. The four Ben Davis trees in the row that I saw last October, together with others had been removed this Spring and there were still other trees in this orchard which were affected. I visited one orchard in which there was a large number of affected trees—in other orchards, there are only a few. The total number of affected trees in the orchards of the Western Slope, is already unfortunately large.

THE PROBABLE CAUSE OF THE TROUBLE.

I have already clearly indicated my conviction that the cause of the trouble is arsenical poisoning; that there are some trees suffering from other causes is quite certain but the cause of the greater

portion of the trouble is the arsenic which has accumulated in the soil. The expression of this conviction is not a hasty one, for I am fully alive to how much it means to this state and all other orchard growing states where similar soil conditions prevail, but it is for the best interests of orchardists that they should know the facts pertaining to the death of their trees and the conditions of their soil.

THE ACCUMULATION OF ARSENIC IN THE SOIL.

The spray material used in combating the codling moth is either a calcic arsenite or lead arsenate. The number of sprayings applied vary from two or three to nine during the season. I do not think that this Station has ever recommended more than three sprayings during the season, but many orchardists apply more. The amount of lead arsenate used is from four to six pounds to each 100 gallons of water. The average orchardist does not consider the amount of arsenic thus applied to a single tree a very large quantity, and he cannot be expected to consider the nature and possibilities of the material that he is applying, so in many cases he applies, as he thinks, wisely, a liberal quantity, sometimes using eight to ten pounds of lead arsenate to 100 gallons of water, and applies eight or ten gallons of the turbid liquid to the tree. If six pounds of pasty lead arsenate be used to 100 gallons of water and ten gallons of the mixture be applied to a tree we have six-tenths of a pound of the pasty arsenate, or in round numbers, three-tenths of a pound of dry lead arsenate.

Practically the whole of this eventually finds its way into the soil. If this be repeated three times during a season we have 1.8 pounds of pasty lead arsenate or 0.9 pounds of dry arsenate applied to each tree, or considering that the dry lead arsenate contains 25 per cent of arsenic acid, we have 0.225 pound of this substance per tree and allowing 80 trees to the acre, we have 18 pounds of arsenic acid to each acre of the orchard. If this amount of arsenic acid were evenly distributed through the first foot of soil, it would correspond to four and a half pounds of arsenic acid for each million pounds of soil, or 4 1-2 parts per million. This arsenic is, however, not evenly, but very unevenly distributed, as the spray mixture runs down the trunk of the tree and accumulates in the soil at its base. It is not done one year only, but every year, unless there should be no fruit. Some of our orchards have already been sprayed for eight or ten years and a few of them for even a longer period, so that we would expect to find a considerable accumulation of arsenic in the soil, especially in the soil at the base of the trees. This corresponds to the facts as found by analysis. In one sample taken beneath the head of a twelve-year-old apple tree, and representing the soil to the depth of five inches, I found arsenic corresponding to 30.6 parts of arsenic acid to each million parts of the soil; in

another, soil 25.5 parts; in another 26.0 parts; in another 38.2 and in still another, 61.3 parts per million. The sample giving 38.2 parts arsenic acid per million was taken at the base of the tree and to a depth of one foot, the last sample, giving 61.3 parts arsenic acid per million, was taken at the base of the tree and to the depth of four inches. All of the samples were taken either in the Spring of the year or at least some time after the last spraying, so that they ought to fairly represent the orchard soils. We find in fact, what was from the beginning patent, namely that the arsenic does accumulate and is already present in our orchards in dangerous quantities, if it, by any means, should become soluble.

THE ARSENIC IS TAKEN UP BY THE TREES.

It is altogether correct that the spray material applied is a compound of arsenic either difficulty soluble or insoluble in water as calcic arsenite or lead arsenate. It is also true that literally hundreds of trees have already died or are sick, as I believe, beyond hope of recovery. The symptoms are the same. The duration of the tree after showing the first early ripening of its foilage is about one year; the attack of the disease is at the same point, and progresses in a uniform manner. Mr. Whipple describes its course as follows:

"The first indication of the disease is the appearance on the trunk of spots of a chocolate color. When peeled off the bark has a peculiar marbled appearance, the diseased portions standing out in sharp contrast to the healthy tissue."

"The disease soon kills the bark and it dries down to the wood, taking on a dark brown color. (Plate II., Fig. 1). Two seasons are required for the disease to kill the trees. The first season the trunk is girdled and the foilage drops early. This early ripening of the foilage is often the most prominent symptom and diseased trees can be easily picked out in the early fall. Trees showing and early bronzing of foilage are generally found girdled by this disease. The second season the tree starts into leaf as the normal tree, generally setting fruit and dies in mid-summer, the fruit and leaves clinging."

I have seen no tree in which the trouble has advanced to that stage indicating its death during the following summer, but that some of the roots, in fact, most of them in nearly every case, had been attacked, the bark destroyed to a greater or less extent, the woody tissue stained brown and the bark at the base of the trunk severely attacked just below the ground. It is from this point that the trouble seems to take its start. Some facts, however, particularly the condition of some of the roots, they being entirely dead, while others standing in just as close a connection with the diseased crown are in much better condition, suggest that the attack may not be confined to the crown. The condition of the crown produced by this trouble is shown in Plate II., Fig. 2, also the stained or discolored condition of the tissue. This is a photograph of a stump of a Ben Davis tree which was removed this spring, and would have died this summer. Plate III., Fig. 3 is that of another Ben Davis tree

from another orchard and shows how the woody tissue is stained. The notch shows where a portion of the stump was removed for the purpose of examination. This tree was in bloom when dug up. It was perfectly representative of a number of other trees in the same orchard which had already been dug up or had been marked for removal. Many trees in this immediate neighborhood are affected in the same manner. The trouble is not confined to one orchard. In this case we found it in four, we might say, contiguous orchards. I have taken portions of at least 14 different trees. They were from a considerable variety of soils and were trees that had just been removed or which we removed ourselves, or are still standing in the respective orchards. So far as I could learn, only two of these trees failed to show some life this season and one of these was a pear tree which we dug up ourselves. This tree had been cut back severely in 1907 and had thrown out a few shoots, some of which had made a fair growth. None of them were trees which had died and remained standing and had had an opportunity to absorb arsenic as dead trees. As stated, some of the trees represented by our collection are still standing and were in full bloom at the time we removed the roots and branches. The condition of the roots and bark, however, was that produced by the long continued action of the poison.

The conditions found are as follows: The bark at the base of the trunk and just beneath the ground is destroyed and the damage extends up the trunk sometimes even into the limbs. (see plate II.) This damage is shown on the trunk by the bark being brown and sunken. On the roots, the bark is disintregated as is well shown by Plate IV., Fig 1, a sample taken and photographed by Mr. Whipple. Often, in the advanced stages of the trouble, the bark is almost charred and the wood itself is even blackened. The tissue is strongly attacked and yields to the rasp like wood charred sufficiently to destroy its fibre. It looks and acts like wood acted on by a dilute acid, sulfuric acid for instance, only the darkening is not, as a rule, so intense as would correspond to the same degree of disintegration by this acid.

The limbs and branches of trees affected in this way usually, but not invariably, present a case of "black heart." The interior portion of the branch is strongly discolored with a margin pronouncedly darker than the rest of the interior. (Plate IV., Fig. 2; also Plate III., Figs. 1 and 2). This condition is usually attributed to another cause, freezing at some time or other, but we have pretty direct proof that in these cases, it probably has been caused by the poisoning of the tree. It is a rule that branches of healthy trees show this difference to a very small extent, they being usually white from the center to the circumference. Even in Fort Collins, where we have severe changes in the temperature,

this seems to be the case. A branch from a neglected tree in my garden is white throughout (Plate IV., Fig. 4). The age of this tree is not less than 15 years, and has to my knowledge been subjected to temperatures ranging as low as -40 degrees F., and often below -18 degrees F. I do not know the early history of this tree, and do not wish to give more weight to the fact mentioned than is due. I have not examined pear trees as carefully as I have apple trees, but the few branches that I have observed were not discolored in this manner. Plate IV., Fig. 3 represents a section of the trunk of a pear tree, killed by arsenic, and shows the manner in which the wood is stained.

Another effect of this trouble is to cause the bark to split and the wound to bleed. (Plate V., Figs. 1 and 2). This result may be partly and possibly wholly induced by another cause. Mr. Whipple suggests that the splitting open of the bark may result from the girdling, but this will certainly not apply in many cases, though it may in some. I have in mind two orchards in which this cracking and bleeding occurs to such an extent that any person whether he were accustomed to orcharding or not would take notice of it. One of these orchards is today rated as a very fine one.

With these general statements concerning the manifestations of the difficulty, I will give the facts on which the statement rests, that the arsenic is not only in the soil but has been absorbed by the trees.

I have taken samples from fourteen trees, eleven apple and three pear trees. These samples consist of roots, stumps, one trunk and branches. I should add to the above two samples of the deposit formed by the bleeding referred to in a preceding paragraph. On these various samples, thirty tests for arsenic were made and its presence was established in every instance. I did not attempt to make quantitative determinations except in a few cases which showed from 1.25 parts to 12.77 parts of arsenic per million of the woody tissue. I found the reaction for arsenic stronger in the roots and crown of the trees than in the branches, but could not with certainty distinguish any difference in the amount of arsenic present in the green or natural colored portion of the limb and the discolored portion.

I do not wish to weary the general reader with technical details, but it is proper that he be assured that the arsenic reported as having been found in these thirty different samples, was not contained in any or all of the reagents used. The proof of this was obtained by using a piece of oak wood and carrying it through as though it were a sample of an apple tree when a negative result was obtained showing that both the wood and the reagents were free from arsenic. This was not the only precaution, for four blank tests were made during the work to make sure that no error should arise from

this source. The care taken was in all ways as circumspect, so far as the analytical work was concerned, as though the examination of human viscera were in my hands. Another source of error lay in the danger of getting some particles of spray material with the bark of the sample. This was obviated by removing the bark from both the roots and branches, before taking the sample for analysis.

In one case, that of a pear tree, the bark was examined; in this case the bark was smooth and sound enough to permit of its being washed with a stiff brush. It gave a fainter reaction for arsenic than the wood which it covered.

With these statements it may fully suffice if I give the details of only two samples a little more fully.

One taken from the trunk of a small pear tree ten years old. Section cut out 30 inches above the ground, bark entirely removed, wood quite generally stained but not deeply so like the roots or central portion of many of the branches of the apple trees. This section is shown in Plate IV., Fig. 3. The wood is hard but rasps easily. I took 60 grams, almost exactly two ounces, destroyed the wood by means of sulfuric and nitric acid; collected the arsenic as arsenate of Iron; dissolved in sulfuric acid and introduced it with proper precautions into an active Marsh apparatus and obtained arsenic corresponding to 2.55 parts of arsenic acid per million. Owing to unavoidable losses, the arsenic obtained is too low.

The second one is a sample of a stump. I cleaned it thoroughly by paring off all bark and soiled portions and rasping it. I took two ounces as before, proceeded in exactly the same manner and obtained arsenic corresponding to 12.77 parts of arsenic acid per million. Every sample was proceeded with in just as careful a manner as these two, and arsenic was easily proven to be present in the tissue of every sample, whether it was taken from the central, the intermediate or exterior portion of the root or limb.

We have seen that the arsenic is accumulating in the soil, having already reached as large an amount as 61.33 parts of arsenic acid in a million of soil.

I have stated in Mr. Whipple's words, the manner in which the trees are affected and have given the description of what I myself found.

Further we have shown that in these dying trees arsenic is present in the roots, the trunk and branches varying up to 12.77 parts per million.

ARSENIC IS THE CAUSE OF DEATH.

So far the question, Is the arsenic really the cause of the corrosion of the bark beneath the ground, the killing of the bark on the trunk, the killing of the roots and the staining of the wood, in short is it the cause of death? has not been answered. I have stated

Colo. Ag. Expt. Sta.

PLATE 1.

Colo. Ag. Expt. Sta.

PLATE 2

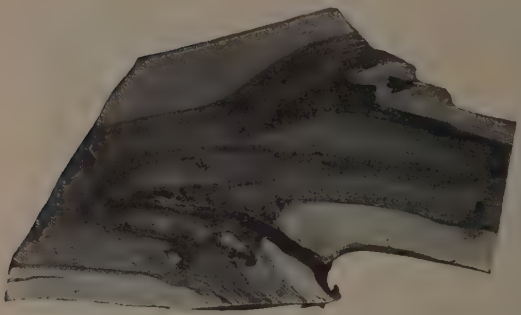

Fig. 2

Fig. 3

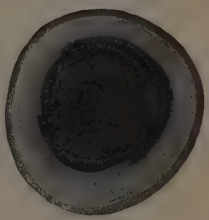

Fig. 1

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PLATE 3.

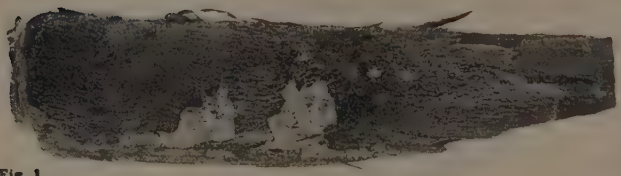

Fig. 1

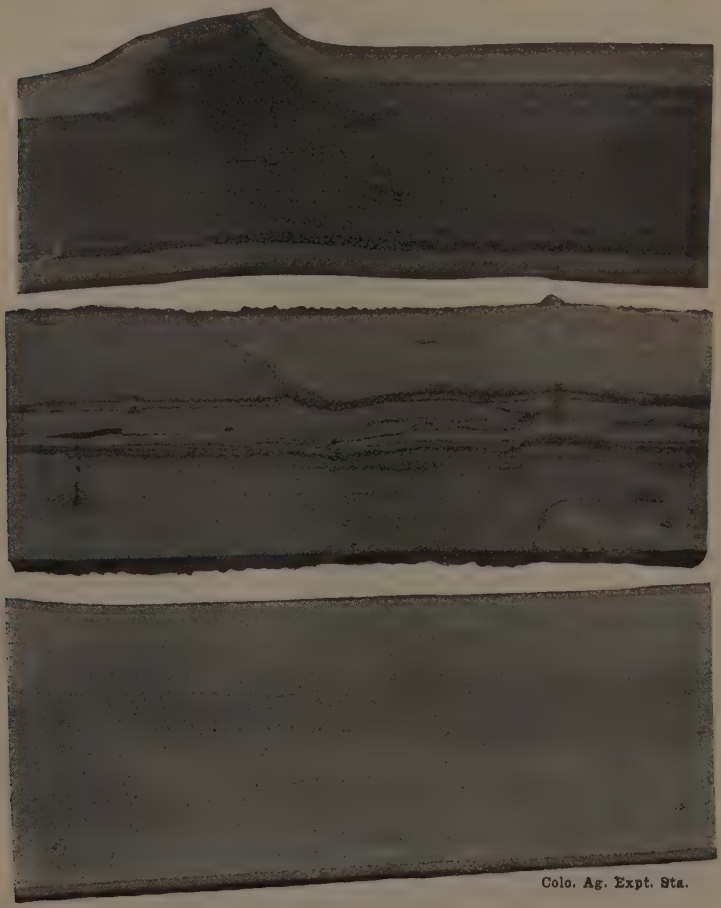

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PLATE 4.

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PLATE 5.

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PLATE 6.

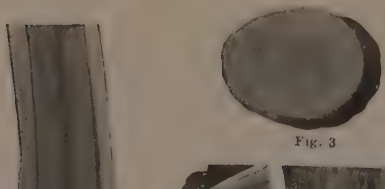

Fig. 3

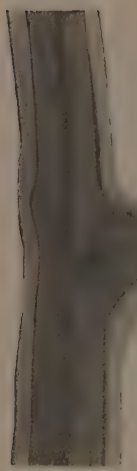

Fig. 1-A

Fig. 2

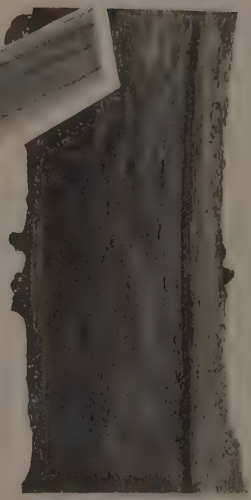

Fig. 4

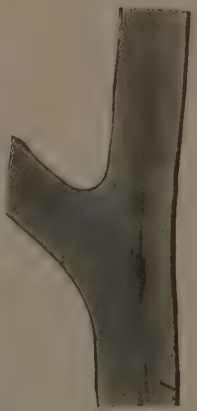

Fig. 1-B

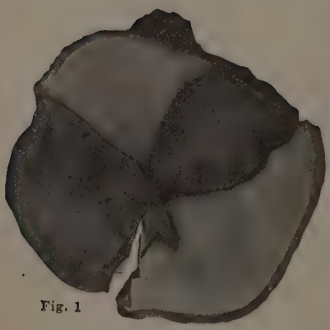

Fig. 1

Fig. 2

Colo. Ag. Expt. Sta.

PLATE 7.

my conviction that many trees have been killed by arsenic and that others are hopelessly sick. I will give some reasons for my belief. First, it is a well known fact that soluble arsenical compounds will kill plants. It has been found that Herbicide, a preparation found on the market, is essentially a solution of an arsenical compound. Both white arsenic and arsenic acid have been shown by various experimenters to be deleterious even when present in very small quantities, one part per million in solution. Second, I took some greenhouse plants, coleuses, daisies and geraniums in two and a quarter and three inch pots and added from 0.05 to 0.5 grams, approximately from 3-4 of a grain to 7.5 grains, of sodic arsenite and the smallest amount used sufficed to kill the plants. Third, I know of two trees, one killed outright, at least this is the testimony of the owner, there is nothing but the stump left at the present time, and the other partially killed. It was my good fortune to see this tree in October last when the affected limb was still on the tree with the dead and blackened leaves clinging to it. Inquiry elicited the statement that it had been killed by arsenic as the other tree had. In the case of the tree that had died and been removed, they had made arsenite of lime under it or near it and had probably spilled the arsenite of soda. In the case of the tree, one limb of which was dead, they had been more careful with their sodic arsenite, having some left over they determined to get rid of it and emptied it into the irrigating ditch near the tree; this was one day in June—two days later the limb was sick. I saw it in October when the limb was dead and had the appearance of having been dead for some time, and again in April last. In the meantime the limb had been cut off but was still lying beside the tree as shown in Plate VI. Mr. Whipple and I measured the distance from the trunk of the tree to the irrigating ditch shown in the foreground of Plate VI., and found it to be 12 feet. An examination of this tree showed that a section of the bark from the base of the trunk up into the big limb was brown, sunken and in appearance like the bark in the trunks of the affected trees. The wood beneath this bark was dead and colored brown, well shown in Plate VII., lower Fig. 2, which shows that nearly the whole section of the limb was involved, and that the bark was sunken and dead. The condition below the surface of the ground was even still more striking for the bark was destroyed and the little that remained was very dark, in places, black. We dug out this root, following it to the irrigating ditch, to the point where the sodic arsenite had been emptied. Two or three feet from the ditch, the root had divided into five branches or rootlets. These were black and brittle. Following these toward the trunk, we could trace the effect of the arsenite by two sections of the bark, one on the upper and the other on the lower side of the root, which had been destroyed and the wood beneath them killed

and blackened. The other two sections of the root were still of a natural color. The roots, two in number which were thrown off to the left of the main root presented a condition contrasting very sharply with the five rootlets and the two sections of the main root for they were apparently entirely normal while the others were black and dead. The condition of this root is shown in Plate VII., Fig. 1, which represents a section of the root taken close to the trunk of the tree—again in Plate VII., Fig. 4, which represents a view of the under side of a piece of this root. The side root was apparently healthy (Plate VII., Fig. 3). The killing of the bark and woody tissue was in this way traced from the point at which the sodic arsenite was introduced into the ditch through the small roots into the large one, thence into the trunk, the limb, and even into the branches. The course was direct and the flow of the poisonous solution was confined to a comparatively narrow channel. The darkened area, "black heart," in the case of these branches is shown in Plate VII., Fig. 1-a and upper Fig. 2, which shows the central discolored area, which is not symmetrical with the annual rings or contour of the limb, and also the border of deeper stained tissue. I am not concerned about any theory of sap circulation, but am simply tracing the discoloring effect of the arsenic through the root into this portion of the branches. We see that the discoloration extends through the root, trunk and central portion of the branch. In this instance, death may be said to have been sudden and it may be assumed that a portion of this effect may be a post mortem one.

We have not simply assumed that the placing of sodic arsenite in the ditch and the dying of this branch of the tree two days later are wholly conclusive as to the cause of death. I have examined the wood of the branches and the root and find an abundance of arsenic in both. In this case, I recovered the largest amount or arsenic found in any sample, namely from the discolored portion of the root, in which I found arsenic corresponding to 34.5 parts of arsenic acid in one million parts of the tissue.

The other portions of this tree were apparently in good condition when I last saw it. An examination of the branches from the unaffected portion failed to show any such case of "black heart" as the affected limb (Plate VII., Fig. 1-b). In fact, they showed nothing which could be classed as a darkened center, though I recall one branch which was clouded more or less.

I have given this case in some detail because I believe it to be as conclusive proof as can possibly be adduced that soluble arsenic compounds not only produce death when introduced into the circulation of the apple tree, but will produce the effects which we find preceding the death of our apple and pear trees. In both cases, we have the killing of the bark, the staining and destruction of the tissue, and the killing of the trees. The "black hearted" condition is

only incidental but in the case of our trees, I believe it to be a very suspicious condition.

I have now given the reasons for my conviction that the arsenic which has accumulated in our soil from the use of arsenical sprays used in combatting the codling moth and other fruit, leaf and bark eating insects is the cause of this trouble. To restate them succinctly, we find the arsenic already accumulated in the soil to an extent far beyond the danger line for solutions as established by competent experimenters. We find it also in the tissues of the plant where it is not normally present; we have proven both in the case of herbaceous and woody plants that soluble arsenical compounds will cause their death.

I regret that I can see no other conclusion than that the corroding of the crowns, the killing of the bark, the staining and final destruction of the woody fiber, the early dropping of the leaves presaging the early death of the tree and its final death a few months later are caused by arsenical poisoning.

SOLUBLE ARSENIC IS PRESENT IN THE SOIL.

In preceding paragraphs, I have made two statements which will help us to explain but in no wise to remedy the trouble. One statement is that the only protection against arsenical poisoning of our orchard trees is the insolubility of the arsenical preparations used in spraying and that their continued immunity from poisoning requires that these arsenical compounds shall not be rendered soluble by any agent in the soil. Again, also in an introductory paragraph, I state that from the standpoint of my own department, this subject was really approached through the study of the effects of the alkalies.

It is certainly true that it is possible that in time, these arsenical compounds might accumulate in the soil to a sufficient extent to enable the feeding roots of the tree to bring enough arsenic into solution to be dangerous to the life of the tree by systemic poisoning. It is useless, however, to dwell upon this possibility when there are known conditions, amply sufficient to explain all the facts. Our soils, especially near the surface, contain from 0.20 of one per cent to upwards of one per cent of alkalies, from 8,000 pounds to upwards of 40,000 pounds of alkalies in an acre foot. A few small areas may be practically free from these salts, but the rule is that they are present. It may be accepted as essentially correct that these salts consist of sodic sulfate and sodic chlorid. There is almost always a small amount of sodic carbonate present, but it is sometimes absent, as is the case in one of the soils in question.

ALKALIES RENDER ARSENIC SOLUBLE.

These so-called alkali salts, sodic-sulphate, carbonate and chloride or to call them by their more common names, Glauber's Salt, Sal Soda, and ordinary kitchen salt, are capable of bringing

the arsenic into solution, even when it is present as lead arsenate. It has often been asked at meetings of these orchardists whether it was a safe practice to use their surface alkali water in applying the lead arsenate and I have stated that it was not a good practice, for one could easily conceive of conditions under which the whole of the lead arsenate could be converted into sulfate of lead and sodic arsenate be formed in the solution. This statement never seemed to be an acceptable one. I have in this case not depended upon any chemical laws, however, evident their adequacy might be, but took well washed lead arsenate, a sample which we found by rigid test to be free from soluble arsenic, suspended one gram of it in 2,000 times its weight of water and added two grams of Glauber's salt, allowed it to stand three days, filtered off a portion of it, concentrated by evaporation and tested it for arsenic. I found that the arsenic had gone into solution in very considerable quantities. A parallel experiment was carried out with salt in which only one gram of salt was used to the 2,000 grams of water. This was not allowed to stand quite three days when 1,500 grams were filtered off, concentrated and tested for arsenic. This concentrated solution was found to be so heavily charged with arsenic, that only a small part of it gave an unmanageable amount of arsenic when brought into an active Marsh apparatus.

A similar series of experiments was made with the lime arsenite. We included in this experiment the salts above mentioned and also distilled water; the lime arsenite was prepared by precipitating a solution of calcic chlorid containing an excess of the lime salt with a solution of arsenite of soda, filtering and washing it. This precipitate was probably the pure normal arsenite of lime. One gram of this lime arsenite was suspended in 2,000 times its weight of distilled water, another gram in a like quantity of water containing two grams of Glauber's salt and a third gram in a like quantity of water to which had been added one gram of salt. The calcic arsenite seemed almost completely soluble in each of the three trials.

We have then direct proof that the alkali salts in the soil are capable of bringing the arsenic, even when present as arsenate of lead, into solution and consequently making it a source of danger.

In regard to the arsenite of lime, there would seem to be but little to be said. I remember having years ago tested the clear solution remaining after the lime and arsenite of lime had settled and as I now recall it, for I have no note on it, the solution was free from arsenic. If this is correct it may have been due to the great excess of lime present.

LIME SALTS IN THE SOIL DO NOT PREVENT THE SOLUTION OF ARSENIC

The idea expressed in the last sentence has persistently presented itself in another form, namely would not the lime salts oc-

curring in our soils, especially gypsum which is notably soluble in water, serve to prevent the solution of arsenic. The answer to this is unquestionably no. For when 500 grams of soil, rich in sulfate of lime, were suspended in 2,000 grams of water and allowed to stand, some arsenic went into solution. This experiment was made three times and the results showed the presence of soluble arsenic so decidedly that there was no reason to seek even for cumulative evidence on this point. It does not, of course, matter where the alkalies came from, whether they were already in the soil or whether they are brought to the soil by the water used for irrigation, some of which I know to be rich in alkali.

CANNOT DISTINGUISH THE SOURCE OF ARSENIC.

I do not know the history of the samples of soil examined whether they contained the arsenic as lime arsenite or lead arsenate, nor does it appear to me to be a matter of importance in which form the arsenic was present in the soil. The experiments with the alkalies, Glauber's salt and ordinary kitchen salt, indicated in my judgment, the greater solubility of the lime salt, but it would be difficult perhaps, aside from the deportment of the lime salt, to prove directly that the arsenic found in the tree had been derived from the lime arsenite for the ash of the tree contains some lime and there is scarcely an orchard soil which has not received both the lead and lime salts. It is impossible to tell which one has contributed more largely to the damage done, but owing to the length of time it has been used and the greater readiness with which it appears to go into solution, it would seem probable that the lime preparation has up to the present, contributed more largely to bringing about the trouble than the lead salt.

It is, on the other hand, easier to obtain direct proof that the lead arsenate has been the source of some of the arsenic for lead is not a normal constituent of woody tissue and the presence of a trace of it suffices to prove that the lead arsenate has been the source of the arsenic. I tested only six of the samples for lead but as lead was found in each of them this number of tests is deemed sufficient. The lead was obtained in the metallic form and its identity established beyond doubt.

The significance of this is not only that lead arsenate has been the source of the arsenic but that the ordinary kitchen salt present in the soil is probably an active agent in bringing it into solution, for the lead chlorid which would be formed by the interaction of the lead arsenate and salt is more readily soluble than the sulfate, the product of the interaction of Glauber's salt and lead arsenate. In this case too, it seems beyond question that both salts, Glauber's salt and ordinary kitchen salt, contribute to the damage done. The amounts of these salts in the soil and in some water used for

irrigation, particularly the Glauber's salt, is more than ample to bring about the solution of the arsenic.

TWO KINDS OF ARSENICAL POISONING.

So far I have not mentioned the character of this arsenical poisoning whether it is a general systemic poisoning or a case of acute irritant poisoning. That the former class of poisoning may occur seems very probable as in the case of one of the pear trees studied but all the rest of the cases with which we have met so far, seem clearly to belong to the latter class. The possibility of the occurrence of the former, however, is a matter for serious concern, for if the soil becomes sufficiently rich in arsenical compounds to enable the roots to appropriate the arsenic as they do the general sustenance of the tree then the poisoning of the tree becomes a question of its ability to tolerate the poison. I fear that we have some cases in which our statement that the beginning of the trouble is at the crown of the tree, is not applicable, though this, as a rule, seems to be the case. Still it is suggestive, as elsewhere indicated, that often the dead roots are not as intimately connected with the affected areas of the crown as those which still retain a little life.

The lead and lime with which the arsenic is combined in the sprays may be appropriated by the tree to its injury. The amount of lime, however, added to the soil as lime arsenite would be wholly insignificant in comparison with the lime already present in nearly all of the soils with which we are concerned in this bulletin unless it were taken up as arsenite of lime.

There are really three substances which might act as poisons to the trees, namely, arsenic, lead and lime.

ARSENICAL POISONING.

I have already discussed the question of arsenical poisoning so far as the purposes of this bulletin demand.

LEAD POISONING.

The question of lead poisoning is a permissible one for discussion, but while lead, as it was found in every sample tested for it, is probably present in all of the samples and may have some influence, the action of the arsenic appears so clearly the important one that the action of lead may be dismissed with this brief mention.

THE EFFECT OF LIME.

This question is one which cannot justly be left wholly without mention. As indicated above the lime and arsenic may be taken up in combination, or it may be simultaneously but not in combination and it would be difficult to distinguish their separate action. There are, however, other questions which involve the case

still further. It is stated on good authority that marly soils are unfriendly to a number of plants. Many of our soils are rich in carbonate of lime and others are underlaid by a stratum of marl, carbonate of lime, sometimes acquiring a thickness of two feet or more. It is a serious question in my mind whether this is not a bad feature. My attitude toward this subject is exactly the same as that toward the one or arsenical poisoning, i. e., that the subject should not be mentioned without good and forcible reasons for doing so. Why mention this then at all?

I have called attention to the fact that many trees, evidently in an unhealthy condition, are bleeding freely from old wounds, stubs, where limbs and branches have been cut off and from cracks in the bark (Plate V., Figs. 1 and 2). This sap is heavily laden with salts of some kind, dries quickly, and deposits a yellowish white crystalline mass. This mass when fresh possesses, at least sometimes, a disagreeable taste; the thoroughly dried salt has not a particularly unpleasant one. I have seen this juice dripping from a crack in the bark and building a veritable stalactite of this material Mr. Weldon, our Field Entomologist, and I gathered a quantity of this material, avoiding as far as possible the scraping of the bark, lest we should get some of the spray material. The conditions exposed our sample to contamination in this manner and by dust, which might contain arsenic, being blown into it, but I think that the results obtained from this sample may be accepted as, in the main, reliable. This material was very rich in arsenic and contained 25 per cent of calcic oxid. I do not believe that the splitting or cracking of the bark and the bleeding are specific characteristics of arsenical poisoning but are attributable to other causes which in these cases may act conjointly with the arsenic. The destruction of the bark by the arsenic is an entirely different thing from this cracking or splitting of the bark.

Having found that this dried sap was an interesting subject, we gathered a second sample. The preceding sample was gathered before the first spraying of the season had been made, but the second was taken subsequently to it. Lead arsenate was used in the spray and might have gathered in this dried juice which forms rough masses on the limbs and trunk of the tree. In order to remove as far as I might be able, such arsenic as might be present as lead arsenate, dust and other impurities, I dissolved the dried sap in as little warm water, not boiling, as possible and used only the aqueous solution in making the test for arsenic which was very abundant indeed.

This sample of air-dried material gave 24.93 per cent of lime, CaO; it contained a little magnesia and alkalies. I have made no attempt to determine the acid combined with the lime, but lime being practically the only base, it seems probable that the mass is essen-

tially a malate of lime which would require 25.7 per cent of this substance, calcic oxid. These trees do not present the symptoms described for the arsenical poisoning, though arsenic is very abundant. The question is—Are these trees suffering from systemic arsenical poisoning, lime poisoning or both? These soils are marly or have a subsoil of this material and the presence of 25 per cent of lime in the dried sap seems to me to be a very suggestive fact.

I have no remedy to suggest for either condition. Preventive measures are so far as I can see, our only recourse. Those which suggest themselves to me are: to remove the arsenic laden soil from about the crown of the tree and replace it with fresh soil; to use the standard brands of lead arsenate in preference to the arsenite of lime or white arsenic, sal soda and lime; to use as little lead arsenate as possible. I have been told that good results have been obtained by using 2 1-2 and even 2 pounds of pasty lead arsenate to 100 gallons of water, but the spraying must be done thoroughly. Spray no oftener than is absolutely necessary. If I am not mistaken Prof. Gillette has found that 95 per cent of the effect of the whole season's spraying was obtained by the first spraying when thoroughly well done. Some device should be used to prevent the spray material from running down the trunk and collecting at its base or it would be still better to make provision for gathering the whole of the drip. Water rich in alkalies should not be allowed to flow close enough to the tree to permit of the deposition of the alkalies in the soil about the trunk of the tree. Concentrated lye, if used to kill the woolly aphis, should not be applied to the soil at the crown of the tree or permitted to flow down and collect there.

SUMMARY

First: There is a large number of fruit trees in the State which are suffering from an affection of the trunk and root.

Second: This trouble begins, in by far the greater number of cases, at the crown of the tree and subsequently involves both trunk and roots.

Third: The first marked symptom is an early ripening of the foilage usually followed by death about midsummer of the ensuing year.

Fourth: The crown of the tree is found to be girdled, the bark on portions of the trunk dead and sunken and most of the roots dead, their bark destroyed and the woody tissue discolored, usually a light shade of brown and sometimes exteriorly blackened.

Fifth. Soluble arsenical compounds will effect the destruction of the bark, the staining of the wood, the production of the so-called "black heart" and the speedy death of the tree.

Sixth: Arsenical sprays have been used in these orchards for a number of years.

Seventh: These arsenical compounds have accumulated in the soil.

Eighth: The accumulation of arsenic in the soil in an insoluble form has already passed far beyond the limit of danger for arsenic in a soluble form.

Ninth: The insoluble arsenical compounds are being converted into soluble ones in the soil.

Tenth: The alkalies are the agents effecting the solution of the arsenic. By alkalies, I mean, sodic carbonate, sodic sulfate and sodic chloride.

Eleventh: The lime salts, viz. the sulfate, gypsum, and the carbonate do not effectively protect the arsenical compounds from the solvent action of the alkalies.

Twelfth: Systemic poisoning may take place, probably does, by absorption of the arsenic with the nutritive solutions taken up by the feeding roots but the greater portion of the trouble appears to be from local irritant poisoning.

Thirteenth: The arsenical poisoning is, in all probability, in many cases, complicated by lime poisoning.

Fourteenth: The arsenic in the arsenite of lime is more readily brought into solution than that of the lead arsenate.

Fifteenth: It is probable that the lime or marl in the soil and subsoil is also an agent acting conjointly with the arsenic in producing some of the trouble.

Bulletin 132. Sept. 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Destruction of Concrete by Alkali

BY

WM. P. HEADDEN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station.

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Destruction of Concrete by Alkali.

BY

WM. P. HEADDEN.

Cement has been found so generally serviceable and beset with so few disadvantages that its use is generally recommended without any reservation, and this confidence has been fully justified with but few exceptions so far as the limited literature at my disposal indicates.

The principal condition under which good portland cement has failed to fulfill the requirements of the structure in which it was used, seems to have been where the structure was exposed to the action of sea water. Such exposure has not resulted uniformly in the destruction of the cement, so that even this condition, i.e., the exposure to sea water, a solution comparatively rich in magnesic chlorid and sulphate, may not have been the determining factor in the trouble noted.

The following case of deterioration may be of some interest as it presents some new points. There were sent to me some months ago a number of fragments of tiling which had been laid but from eight to nine months. They had been disintegrated to such an extent that one of the samples was simply a white putty-like mass mixed with sand. There was nothing about this sample remotely suggestive of concrete. Another of the samples consisted of a fragment of the tile, the interior portions of which had been wholly decomposed, while there still remained an outer and inner portion in good condition, or comparatively so. Another sample had been attacked on the inner side leaving the mass of the tile outside of the zone of decomposition apparently sound. The line of decomposition was sharply limited and showed distinctly, but even in this case there remained a thin layer of cement on the inside.

I do not know whether the tile were running full of water or not, probably not, as the fragments seem to be parts of 16 or 18 inch tile. The importance of this point is simply this, that it would answer any question in regard to the separation of solid "alkali" salts on that portion of the tile above the water line. That such a separation of these salts should take place does not seem very probable in this case.

The point of attack so far as the samples at my disposal indicate, is either in the center of the cement mass or near the inner surface. In either case we are almost compelled to assume the action of the water, i. e., of the salts held in solution. At the same time we see the resisting power of the outside and inside surfaces, which are evidently richer in cement than the inner portion of the mass of the tile.

The sand used in making the tile was quite fine.* The proportion used was 5:1. We can readily see that the individual masses of cement in the interior mass of the tile must be small and readily attacked by solutions of salts capable of reacting with the cement.

It seems quite evident that the agents causing this disintegration of the cement must gain access to the interior portion of the mass of the tile

*I do not know the character of the water used.

in the form of a solution, but it is a question whether this solution is the same in strength and character as the water in the drain. I think that I have clearly shown in Bulletin 65 of the Colorado Experiment Station, page 34, that the water soluble portion of the soil is different from the salts held in solution in the ground water. Further in Bulletin 72, page 28 **et seq.** that the ground waters are different from the drain waters, and the action of these waters on the tile would vary somewhat according to the source of the solution which penetrated the mass of the tile.

The drain waters obtained, say at a depth of four feet, contain as a rule a smaller amount of salts in solution than the ground water. The salts present are the same but their relative quantities vary. The usual salts present in the ground waters are, sodic sulfate, calcic sulfate, magnesic sulfate, sodic carbonate, and sodic, in some instances also magnesic chlorid. In the drain waters we have the same salts but their relative quantities are different, the most notable feature being the relatively large amount of sodic carbonate.

The substances claimed to be the most active in effecting the disintegration of cement are the sulfates. In the case of sea water the explanation offered is that the lime of the cement decomposes the magnesic salts present in the water whereby the lime goes into solution and the magnesia is deposited in its stead, causing a bulging and disintegration of the work owing to its greater bulk. The principal magnesian salt in sea water is the chlorid, the deleterious action of which on cement is not established, but it has been shown that magnesic sulfate acts energetically.* The most active agent in decomposing concrete is the sulfuric acid of the sulfates carried in solution. Again solutions of gypsum have been shown to act detrimentally on concrete by forming with the tri-calcic aluminate a sulfo-aluminate.

The water acting on these tiles whether it be ground water or drain water is very bad. One of the two small samples sent to me contained 1252.6 grains per imperial gallon, of which 493.5 grains were sulfuric acid (SO_3) with an extremely large proportion of magnesia. The other contained 542.3 grains per imperial gallon, with 42.31 grains of magnesic oxid or 7.8 per cent. of the total solids. I have examined a number of waters from this section and find the ground water uniformly heavily laden with the sulfates of lime and soda with comparatively large quantities of magnesia, especially if the water comes from near the surface as it necessarily must in the case of drain waters. In addition to the above constituents, there is uniformly some carbonate present which for the present purpose we may consider as sodic carbonate.

We have then an ample supply of these substances present which are known to act deleteriously upon cement, i.e. the sulphates, a portion of which is magnesic sulfate, and in addition there is so much sodic carbonate present that its action cannot be neglected.

For the present I will assume that the cement used was at least an average Portland cement with not more than two per cent. of calcic sulfate added. Assuming this to be correct, the action of the waters on the tile shows an interesting line of action.

A preliminary examination of the white decomposition product indica-

*Taylor & Thompson Concrete Plain and Reinforced P. 401.

ted the presence of a large amount of water, also of considerable quantities of sulfuric and carbonic acids. The decomposed mass was washed with distilled water to remove as much sand as possible. Examination of the wash water showed that it had taken sulfuric acid, lime and soda into solution. The portion soluble in distilled water may have been partly derived from other sources but probably came, for the most part, from the altered cement. The wash water, therefore, was evaporated to dryness and the residue added to the insoluble portion and the whole dried at 60°C. The material thus prepared was submitted to analysis with the following results; with which is also given an analysis of a sample of the same brand of cement.

PORTLAND CEMENT DECOMPOSED BY ACTION OF ALKALI WATER

	Original Cement	Decomposition Product*	Same calculated on water free basis
SiO_2	22.55	10.98	14.16
SO_3	1.29	15.56	20.07
CO_2	1.07	9.39	12.16
Cl_1	not det'd	0.51	0.65
P_2O_5	.....	trace	.....
CaO	59.86	29.14	37.58
MgO	1.75	5.79	7.46
Al_2O_3	5.88	2.08	2.68
Fe_2O_3	4.83	2.51	3.23
Mn_3O_4	0.21	trace	.....
Na_2O	0.76	1.27	1.63
K_2O	0.63	0.29	0.38
H_2O Ignit. less CO_2	0.72	(22.48)	.....
	99.55	100.00	100.00

The loss on ignition in the analysis of the decomposition product agreed fairly well with that obtained by difference, but owing to the presence of alkalies, carbonates and sand the results of direct ignition are not to be relied upon except to show that the difference indicates the amount of water present with reasonable accuracy.

The composition of the water acting on this tiling may safely be assumed to be represented by the following analysis of a sample of Arkansas river water, essentially a return water, taken at Rocky Ford.

The summation of the analysis presents a rather large excess over one hundred which gives an excess of about one grain in the total amount of salts present. The excess of bases shown in the analysis as combined is not necessarily due to bad analytical work. The waters of our mountain streams show an excess of acids over the bases, but the alkalies forming efflorescences on our soils and alkaline waters, frequently show an excess of the bases, but seldom so large as in this case.

*6.01 per cent. sand deducted.

ANALYSIS OF ARKANSAS RIVER WATER, TAKEN AT ROCKY FORD

Total solids per imperial gallon 156.4 grains.

Analytical results.	per cent.	Combined	Grs. Imp. Gal.
SiO_2	0.428	Calcic sulfate	64.942
SO_3	48.299	Magnesic sulfate	27.994
CO_2	1.858	Potassic sulfate	0.942
Cl	4.667	Sodic sulfate	32.449
Na_2O	18.662	Sodic chlorid	12.044
K_2O	0.326	Sodic carbonate	7.007
CaO	17.090	Sodic silicate	1.358
MgO	5.993	Ignition	6.797
Ignition	4.346		
Sum	101.669	Sum	153.533
Oxygen equiv. to Chlorin...	1.051	Excess sodic oxid	3.832
Total	100.618	Total	157.365

The ground waters of the Arkansas valley have essentially the same composition; they of course, vary in the amounts of mineral matter, total solids, held in solution. The two small samples of drain water sent with these tiles illustrate this very well, one of them carried 1252.6 grains, while the other carried less than one half as much, 542.3 grains in an imperial gallon.

The salient featurers in the composition of the salts present in the ground waters of this section are the large amount of sulfates and the presence of carbonates. The amount of chlorine or the corresponding chlorids is not large and are probably subordinate agents in the alteration of the cement.

Mr. R. Feret says*; "No cement or other hydraulic product has yet been found which presents absolute security against the decomposing action of sea water." Further, "The most injurious compound of sea water is the acid of the dissolved sulfates." Again the same writer says; "It is noteworthy, however, that chloride of magnesia is almost without action, while the sulfate of magnesia acts energetically upon cement. * * *"

It has further been established by Candlot, Michaelis and Deval working independently, that calcic sulfate unites with calcic aluminate forming a hydrated sulfo-aluminate which expands greatly on crystallizing and is soluble in water.

It is assumed that magnesic sulfate acts upon the calcic hydrate set free by the setting of the tri-calcic silicate, forming calcic sulfate which is then capable of uniting with the calcic aluminate with bad results.

The ground waters found in the lower portions of our irrigated sections contain a mixture of the sulfates of soda, lime and magnesia, with which there is usually associated some carbonate. Some of these waters are essentially solutions of sodic sulfate with a little sodic carbonate; others especially drain waters contain calcic and magnesic sulfates with some carbonate, possibly sodic carbonate.

*Taylor & Thompson Concrete Plain & Reinforced. P. 400.

The knowledge of the fact that our drain waters contain carbonates led me to try the action of a mixture of sodic sulfate and carbonate on the coarsely ground concrete. This mixture attacked the cement rapidly yielding a white decomposition product rich in carbonic acid. This result is no other than what we would expect. If the tri-calcic silicate in setting really liberates four molecules of calcic hydrate, as we suppose the reaction should be accompanied by the liberation of a corresponding amount of sodic hydrate. The following formulae will make this point clear:

$$2(3CaO.SiO_2)+9H_2O=2(CaO\ SiO_2)5H_2O+4Ca(OH)_2.$$

The calcic hydrate liberated or very loosely held can readily act on the sodic carbonate as indicated by the following simple formula;

$$4Ca(OH)_2+4Na_2CO_3=4CaCO_3+8NaOH.$$

The sodic hydrate thus freed is capable of further attacking the silicates and possibly the aluminates, carrying silicic acid, alumina and lime into solution, probably as hydrated silicates. The treatment of the cement with a mixed solution of sodic carbonate and sulfate showed that it is a fact that calcic carbonate is formed and also that silicic, alumina and lime do go into solution and that too without the aid of free carbonis acid.

No care was taken to make the solution of mixed salts even approximately of the same strength, as the ground waters, and no ratio between the salts was observed, simply, that the solution was a weak one; two to three grams of sodic carbonate to the liter with five or six grams of the sulfate The time of the experiment was 14 hours. The time was short, and the solution not as rich in salts as some of our ground and drain waters. The tiles on the other hand are exposed to the action of similar solutions, some weaker but others stronger from the time of being laid till taken out, in this case eight to nine months. In view of these considerations it is not strange that the mass of concrete should be softened and destroyed.

Using the results of these rather crude experiments we may interpret our analyses as indicating that the cement has been deprived of silicic acid; it originally contained 22.50 per cent. but the hydrated decomposition product contains only 10.98 per cent or 14.16 per cent calculated on a water free basis. While the ratio of the weight of the decomposition product to the original weight of the cement is not known, there is no evidence that there has been any increase in the weight which would invalidate the preceding observation and a second experiment with cement and a solution containing sodic sulfate and carbonate leaves no question about the removal of silicic acid, alumina and lime by waters containing these salts. The analyses also suggest the removal of a relatively large amount of lime. The cement contains 59.56 per cent. of lime while the alteration product contains but 37.58 per cent. (calculated on a water free basis). Further the ferric and aluminic oxids have been reduced to about one half as much in the decomposed cement as there was in the original. The sodic sulfate, more particularly the calcic and magnesic sulfates which are present in the ground water will at the same time act on the tri-calcic aluminate, forming the sulfo-aluminate $2(3CaO\ Al_2O_3)+5CaOSO_3$, which crystallizes with 60 molecules of water and is soluble. That these reactions really have taken place is indicated by the increase of the sulfuric acid SO_3 which amounts to 20.07 per cent. and likewise of the carbonic acid which amounts to 12.16

per cent. of the water free decomposition product, while they amount to only about 1.0 per cent. each in the original cement.

That the magnesic sulfate also participates in producing the deterioration is indicated by its presence in the altered cement to the extent of about five times the amount present in the original; i.e. 7.46 per cent. in the water free alteration product against 1.75 per cent. in the original.

The changes effected in this case are quite consonant with the views quoted excepting the formation of so large a proportion of carbonate, evidently calcic carbonate due to the action of the sodic carbonate in the ground water. The presence of sodic carbonate in a solution so rich in lime may seem improbable, but this has been shown to be not only possible, but a fact.

This alteration product differs materially from those produced by the action of sea water on the works at Aberdeen and analyzed by Prof. Brazier (Redgrave and Spackman, Calcareous Cements. p. 285.) according to which the chief decomposition products were calcic carbonate with calcic and magnesic hydrates, while the amount of the sulphuric acid was scarcely altered at all. The analyses indicate a removal of the ferric and aluminic oxids from the interior portions of the work, and an increase of them in the outer portions. The authors after giving the analyses justly make the following statement: "We may observe with respect to these analyses that both in the case of the original cement and the deteriorated concrete, there are many matters which we are quite unable to reconcile."

The action of the ground waters seems to have been one of chemical change converting the lime of the cement into a sulfate and carbonate accompanied by the removal of silicic acid, alumina and lime and totally destroying the cohesiveness of the concrete.

The samples of deteriorated tiles sent to me do not justify any inferences whatever in regard to the part that may have been played by the expansive force of newly formed crystallizable compounds. The thickness of the tile and the amount of material involved is so small that this factor is negligible and the results presented are probably wholly due to chemical action.

This subject is of some importance as concrete structures, bridges, culverts, foundations, etc., are being erected in places where they will be subjected to the action of such waters.

Most of the cretaceous shales are, so far as my observation goes, rich in alkalies, calcic sulfate, etc., and concrete foundations laid in these may be acted on prejudiciously.

As the work in this article was about completed, I received Bulletin 69 of the Montana Experiment Station. The attention of the writers of this bulletin, E. Tappan Sannatt, and Edmund Burke, was called to the deterioration of the cement mortar used in the construction of the sewer system of Great Falls, Montana, by the City Engineer, C. W. Swearinger.

This bulletin gives some excellent illustrations of deteriorated mortar and a general description of the conditions as they found them, also some suggestions relative to their local conditions and recommendations in regard to foundations and other structures made of concrete, but there is no chemical work done on the cement and the products of its alteration. Such work is promised for some future time.

Bulletin 133 Sept. 1908

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OF THE

Colorado Agricultural College

A Few Orchard Plant Lice

BY

C. P. GILLETTE
AND
E. P. TAYLOR

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

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A FEW ORCHARD PLANT LICE

C. P. GILLETTE AND E. P. TAYLOR*

Among the worst insect enemies of the Colorado orchadist today are a few species of plant lice. The codling moth used to be our queen of orchard pests, but the apple growers have learned to successfully combat this insect by means of arsenical sprays.

The plant lice, or aphids, illustrated and discussed in these pages, are not the only ones that fruit growers have to contend with, but they are the species needing the closest attention at the present time in Colorado orchards, and when one has learned to combat these, he will be able to apply the proper remedies for the destruction of most other kinds that he is likely to come in contact with. It has been thought best to give a rather full account of the life habits of the lice here mentioned so that the fruit grower may better understand the methods of control.

The colored plates have been prepared at considerable expense that the reader may better recognize these pests. We believe the bulletin will help those who read it to understand that different plants have different species of lice infesting them, and that these lice often have very different life habits and require different means of control. The lice that infest any plant never appear spontaneously, but every louse, like every higher or larger animal, is the offspring of a parent of the same kind. Consequently all the lice that infest our plants were either native, living upon Colorado wild plants before white men came here, or they have been carried to our orchards upon nursery stock from other parts of the world.

GENERAL STRUCTURE AND HABITS OF THE PLANT LICE (*Aphididae*).

There are a large number of species belonging to the group of insects commonly designated as "aphids" or "plant lice," which have a remarkable similarity of structure and general habits. A knowledge of the more important structural characters of these

*The general direction of the studies here reported, the determination of species, all descriptions, and many of the field and insectary records were made by the writer of this note. The extensive field experiments with remedies upon the Western slope, as well as many life history and food plant notes, were made by Mr. E. P. Taylor, while acting as Field Entomologist for this station. A large portion of the life history and food plant notes, both in the field and in the insectary, have been by Mr. L. C. Bragg. The illustrations are all by the department artist, Miss M. A. Palmer, with the technical descriptions before her. Miss Palmer always draws from her own measurements of parts and when her measurements and mine do not tally, we reach a joint agreement before she proceeds. So I believe the drawings will be found, structurally, quite reliable.

The technical descriptions, with some additional notes upon life habits, have been sent to "Journal of Economic Entomology" for publication.—C.P. GILLETTE.

lice is necessary to enable one to distinguish the species from one another or to understand the descriptions. A knowledge of the general habits will be of great service in enabling one to decide what remedies to employ for the destruction of any of these lice when found infesting plants in general.

EXTERNAL STRUCTURE OF THE APHIDS.

The more important structural parts of an aphis are clearly shown in Fig. 1. The antennae upon the head are special organs of touch and probably smell also. By means of them the insect is able to find its food plants and its mates. The cornicles, standing out from the posterior part of the abdomen, are little tubes through

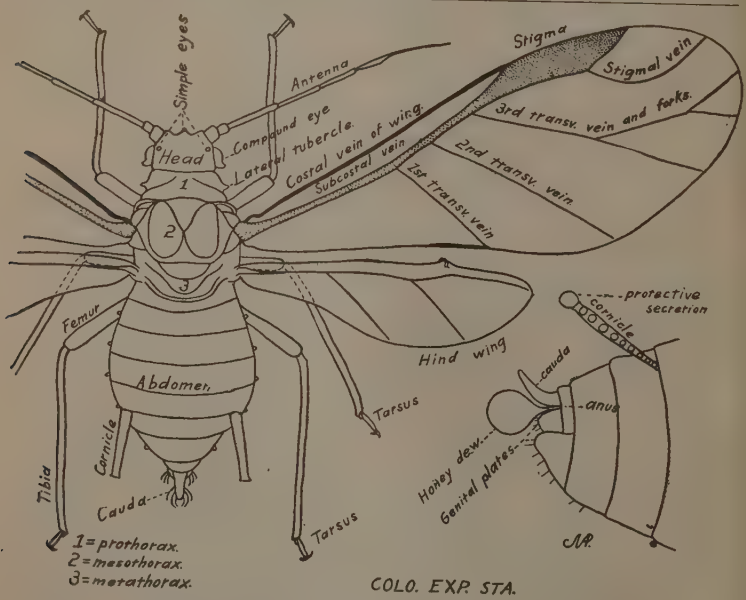

Figure 1. External Structure of an Aphis.—M. A. Palmer, artist.

which the louse expels a sticky material of various colors in different species, as green, yellow, red, black, white, etc. This secretion is probably for the purpose of defense against enemies, but these organs are never for the purpose of expelling the little clear drops of "honey dew" which are so eagerly sought after by ants and sometimes flies, bees and wasps, for food. The honey dew is expelled from the anal opening beneath the cauda, as shown in the smaller drawing, Figure I. The beak, through which the lice

suck the sap of plants, is beneath the head and does not show in the figure.

Each species of plant louse has its special food-plant or plants upon which it feeds. Some species are very restricted in food, having but one, or at most a very few closely allied plants, to live upon, while other species have a few preferred plants but also attack others in smaller numbers, and under certain conditions may adopt a very wide range of plants, especially in the spring, when nearly all growth is tender and succulent, and again in the fall after the preferred food plants may have ripened or have been killed by frosts.

Perhaps one of the most important things to be known, from an economic standpoint, is that very many plant lice have a regular alternation, or change, of food plants. Such lice usually migrate upon certain trees or other woody plants in the fall, upon which eggs are deposited to remain over winter and hatch in the spring to start the next year's broods. These spring forms, after going through one or more generations, acquire wings and go, either wholly or in part, to their summer food-plants, which are usually plants that will die down in the fall.

But it is a condition that we face. The lice are in our orchards. How can we recognize them? What are their habits? How can we prevent their injuries to the fruit crops? These are the questions we shall specially attempt to answer, for the fruit growers.

APPLE PLANT LICE

THE WOOLY APPLE APHIS

(*Schizoneura lanigera* Hausm.).

Plate I, Figs. 9, 10, 11, and Plate III, Figs. 3, 4.

If Colorado orchardists should vote their opinion as to what ought to be called the worst orchard pest in the state, it is very doubtful whether the codling moth, or the woolly aphis, would carry off the honors.

Most plant lice are leaf feeders, but this one confines its attacks to the tender bark, and it is not particular whether it is the bark of the trunk, limbs or roots, if it is only tender enough to enable the louse to insert its beak. When very abundant the lice sometimes attack the stems of the leaves and fruit.

PAST HISTORY.

No one seems to have determined with much certainty the native home of this insect. In fact, it may be said to be a louse without a country, as it is everywhere disowned. The earliest references to it that we have found dates back to 1787, when it was

reported upon apple trees in England. Harris, in his "Insect Injuries to Vegetation," states that the louse had been known in France several years earlier than this. In 1801 it was reported in Germany by Hausmann, who described it and gave it its scientific name. In 1810 it had become so abundant in Gloucestershire, England, that the farmers feared they would have to stop making apple cider, and it is still a serious pest there. In England it was early believed that this insect was first introduced upon nursery stock from America. Buckton, an English writer, in his "Monograph of British Aphidides," seems to believe that this louse is a native of America, and states that it has been known to occur upon the American crabapple;* but the first record we have of the occurrence of the woolly aphis in the United States is in Harris' "Insects Injurious to Vegetation," published in 1841, more than a half-century after it had become a recognized pest in Europe.

In England, before the real cause of the mouldy appearing trees had been discovered, this malady was called American blight. On account of the blood red stain, caused when this louse is crushed, the Germans have called it the blood louse. But wherever this insect may have its native home, and whatever may have been its native food plants, we know that it now occurs in practically every apple-growing region on the globe and, as it is an insect of much economic importance in Colorado, we shall go rather fully into its habits, life history, and means of control.

THE LOUSE DESCRIBED.

Most orchardists will think a description unnecessary, and to them it would be were it not for the fact that there are many other woolly lice upon other plants that are frequently mistaken for the woolly aphis of the apple.

The name woolly aphis was given because of the white secretion occurring so abundantly upon the wingless lice, and, to some extent, upon the winged ones also. This is not a woolly covering in the sense that it grows like wool or hair. It is really a fatty or waxy secretion similar to the shellac, China wax, or beeswax of commerce. Small glands beneath the skin give off delicate white threads of this material through minute pores. This white secretion, when warmed, will melt like tallow. It is easily removed from the body, but in a short time the body will be covered again. It serves as a protection to the louse against storms, and, to some extent, no doubt, from its insect enemies.

*Buckton probably had in mind the statement made by Fitch in his first N. Y. report, p. 5, in which he says he has seen the winged form of the woolly aphis numerous in groves where he suggests that it had come from the shad-bush (**Amelanchier sp.**). It is altogether probable that Fitch mistook the winged form of **Pemphigus corrugatus** Sirr. for winged migrants of the woolly aphis of the apple.

The body beneath the wool is of a rusty or purplish brown color in the fully grown lice, but the very young are much lighter colored. The winged lice are recognized in patches of the white secretion by their long, dusky wings. The thorax and head are black, or nearly so; the abdomen is a dark yellowish brown, and the legs, eyes and antennae are also black or blackish. The last lice in the fall, those that live over on the tree above ground (Fig. 11), are of a dark yellowish to dusky brown color, without the cottony secretion, and would not be recognized as the same insect at all by one not familiar with this stage in the life history of this insect.

LIFE HISTORY.

The life history of this pest of our apple orchards is most wonderful, some stages of which are still not well worked out. Upon the roots, the wingless lice may be found in all stages of development at any time of the year, reproduction and growth taking place more slowly or ceasing entirely in cold weather. Apparently the weather is never cold enough to kill the lice that are well beneath the surface of the ground. We have occasionally found winged lice beneath the surface of the ground when digging about the roots of trees, but we have never found the true males or females or eggs upon the roots. So the lice are always carried through the winter in large numbers upon the roots of the trees, and many of the small lice have often been seen in the spring and early summer migrating up the trunks of apple trees, some of which, undoubtedly, lived over winter upon the roots, or are the offspring of those that did. This does not mean that there is anything like a general migration of the root-lice upward in the spring, for we have no reason to think that such is the case. Neither do lice that are half-grown or more seem inclined to change their locations. Only the very young seem to travel about.*

Upon the trunks and branches of the trees we have, then, four possible sources of the lice in the spring; the little brown lice that descended mostly to the crowns of the trees in the fall to spend the winter; lice from the roots, whose ancestors lived upon the roots the previous summer; young lice of the last fall brood that were able to withstand the rigors of the winter upon the trunk and branches, and lice hatching from eggs that were deposited the previous fall by the sexual females.

From our observations, the most important of these sources is the first mentioned, and the least, if of any importance at all,

*Since writing the above, a letter from Mr. George P. Weldon, Field Entomologist, located at Delta, Colo., dated June 25, '08, says: "I notice only very small lice are trapped in Tanglefoot bands, indicating that the larger ones do not migrate at all."

the last one. Much careful observation has not rewarded us by the finding of a single sexual male or female or an egg of this louse out of doors upon an apple tree under normal condditions. Professor F. V. Theobald, of the South-Eastern Agricultural College, at Wye, England, in his "Report on Economic Zoology," 1907, says: "The egg stage takes place close to the base of the tree, always, however, above ground level. These ova remain frequently hidden in the crevices of the bark all the winter, and in spring they produce a larva which soon matures into the 'mother-queen' form, and which sets to work at a great rate to produce viviparous young." Whether Professor Theobald is reporting his observations or is reasoning from analogy we are unable to say. We know from the actual observations of the writers and by Mr. L. C. Bragg, that such a method of procedure is pursued by the elm woolly aphis, *Schizoneura americana*. The fall winged lice of this species that give birth to the sexual forms sometimes accumulate in thousands about the bases of elm trees to deposit the sexual forms, but we have been unable to discover such a habit for the woolly apple aphis. We are not averse to believing that it has such a habit, but we have not been able to discover it and do not feel sure that Prof. Theobald intended to announce that he had for this species.

During the winter of 1906-07, when the thermometer barely reached zero in the Grand Valley about Grand Junction, and only reached —9.3 degrees at Fort Collins, the lice lived over winter in large numbers upon the trunks and branches. As a result, in the Grand Valley especially, this louse was the most numerous the following spring and summer that we have ever known it in the state. Fortunately, the lady beetles (Plate II, Figs. 12, 13, 14, 15) aphis-lions (Plate I, Fig. 15), and syrphus larvae, came through in good condition, too, so that by the first of August scarcely any of these lice could be found anywhere in Colorado above ground.

Last winter (1907-8) the temperature went several degrees lower, and at Fort Collins there were several nights when the temperature went below zero, yet quite a number of the little, dark, over-winter form of this louse lived through in old scars and beneath the dead bodies of the lice of the previous fall.

How many of those that migrate upward from the crowns of the trees in the spring are really from the roots, and how many are the over-winter form from the tops that went down in the fall, it is impossible to state with certainty. Tanglefoot bands put about the trees early in the spring caught large numbers of the ascending lice at the lower margin and apparently the greater proportion, early in the season, were the over-winter form.

If the lice have lived over in any great numbers, a man with a good hand glass (which every fruit grower should have) can easily detect the fresh white secretion appearing in the old scars.

All the lice appearing upon the trees or roots during spring and summer are viviparous females. That is, they are lice that give birth to living young without the intervention of males. Probably these lice live about three weeks after becoming mature, during which time they will give birth to from 75 to 125 young. These young require about ten days to mature and, like the parent, give birth to their quota of young and die. This process continues generation after generation, all the lice being wingless and viviparous until about the first week in September, when in some of the colonies, winged viviparous females will begin to appear in small numbers. They soon leave the colonies and take wing, and to the present time we have entirely failed to determine what becomes of them. When inclosed by cheesecloth so they cannot escape, they persist in crawling about over the walls of their cage and never return to the tree. Before dying, they give birth to the true male and female lice, but this is either done upon the walls of the cage or upon the inclosed trees. They act like a fall migrant of a louse having an alternate food plant and possessed of an instinct to desert the old one. It is possible that the bad behavior of the lice has been due to the artificial conditions under which they have been studied. We believe Professor Alwood was the first to observe and describe the true male and female of this louse,* and his observations also were confined to the laboratory.

The winged viviparous females appearing in the fall give birth to from six to twelve young, about half of which are males and half females. These egg-laying females are yellowish brown in color and are about half as large as the common adult apterous females. The male is rather light yellow in color and is considerably smaller than the female, and neither grow after being born, having no mouth parts with which to take food. The female develops one large yellow egg that is fully two-thirds as long as her own body. The female is also wingless. Ten winged females were dissected and from them were obtained males and females, as follows:

* Bull. 102, Virginia Experiment Station, p. 139, and Spec. Bull. (C. P. C. No. 45), p. 12, of the same station, 1904.

MALE AND FEMALE BIRTH RECORD OF WINGED MIGRANTS

	MALES	FEMALES		MALES	FEMALES
Louse ----1	4	5	Louse --- 9	2	4
" ----2	5	5	" ---10	4	5
" ----3	3	5	" ---11	3	6
" ----4	3	5	" ---12	4	5
" ----5	3	4	" ---13	4	5
" ----6	4	1	" ---14	3	4
" ----7	5	2	" ---15	4	5
" ----8	3	2	" ---16	4	3

In a state of nature these remarkable instincts and life habits were not developed without a very deep-seated cause. One purpose seems to be to enable the aphis to get away from its mortal foes and continue its existence. The lady beetles * and other predaceous enemies are likely to become so numerous late in the season as to exterminate the colonies of woolly aphis, but if such a thing should happen, the eggs deposited by the true females will start a number of new isolated colonies another spring away from the old haunts of the enemies, and in this manner greatly increase the probability of the continuation of the species. Probably another equally important consideration is the increase of food supply through the dissemination of the species.

When cold nights come on, about as winter apples are being picked, many of the young lice (Fig. 11) do not locate, take on a dusky to dark greenish color, do not grow or secrete any cotton or shed their skins, and seem to be developed for the special purpose of withstanding the winter's cold to start another round of woolly aphis life the next spring.

If a tree top is badly infested, these specialized young will crawl down the trunk in countless thousands in the fall. We have often seen them abundant enough to very perceptibly darken the trunk of the tree and the earth for some inches about the crown. Great numbers crawl into crevices in the earth, about the crowns of the trees, and others get into every possible hiding place beneath loose bark, in cavities of rotten limbs, in old scars and other places that will afford a little winter protection.

Apparently, all the lice in our Colorado climate that insert their beaks and begin taking nourishment in the fall are killed when severe freezing weather comes on. By far the greater num-

*We have found **Hippodamia convergens** to be by far the most abundant lady beetle attacking this louse. **Coccinella transversalis, C. transversoguttata,** and **C. monticola** we have also found feeding upon them to some extent.

ber of the over-winter lice perish, but a few find sufficient protection to enable them to withstand the cold and they start new colonies in the spring. Our tanglefoot bands have caught large numbers of these lice upon the lower half in the spring, and enormous numbers in the upper half in the fall.

PARTS OF TREE MOST ATTACKED.

A great deal of digging about the trees in orchards of the Western slope proved that very little harm is done to roots that are more than 10 inches below the surface of the soil, and more than three feet from the crown of the tree. If water sprouts are allowed to grow up about a tree, they are almost sure to be very lousy, especially just at the ground.

Succulent and rapidly-growing parts, especially grafts, are very susceptible to attack.

Of all the varieties grown in Colorado, the Missouri Pippin seems to be worst infested, and Northern Spy is practically exempt. We have yet to find a single tree of this latter variety much infested. In a few instances slight infestation has been found in pears.

Loose, porous soils seem more favorable for the development of this louse upon the roots than are the heavier and more compact soils.

INJURIES.

The woolly aphis belongs to a gall-producing group of plant lice. Their punctures in the bark have an irritating or poisoning effect, which results in an increased flow of sap, which is to the advantage of the louse, and at the same time it causes an abnormal growth of the part. Very small rootlets may have lumpy galls of considerable size (Plate III, Fig. 4), and larger roots may have an aggregation of these swellings involving a large portion of the root surface. As a result of these attacks, the roots often die and rot and sometimes the condition is so bad that a tree may be pushed or blown over because of the number of roots that have died near the crown of the tree. When the lice attack the tender bark about a scar, upon trunk or limb, the new growth is made more or less gnarly, but the effect is not so pronounced as upon the roots. The lice also attack the tender bark of the small limbs, and particularly where rapid growth is taking place, so that grafts and water sprouts are usually worse infested than other portions of the tree. Upon these rapidly growing parts the lumpy growths often become very numerous. The galls are usually smooth but often crack open, and especially is this true in cases of severe infestation.

If this louse is very abundant, either upon roots or limbs, the result is an unthrifty tree, bearing small and poorly colored fruit. Even if the fruit is worth picking it will be more or less smeared with the excretions of the lice, and the pickers may have their clothing almost completely colored with the red juices of the crushed lice.

Probably the injuries to the tree are greatest from the root attack, but the direct losses to the orchardist are doubtless greatest from the injuries to branches and fruit.

PREVENTION.

Prevention is usually much better than any remedy, but we are seldom aroused into action until we are hurt, and money spent on preventive measures is likely to be considered money thrown away. The greatest care should be exercised to avoid setting young trees with woolly aphis already upon them. Such trees have a severe handicap from the first. To avoid this handicap purchase trees, so far as possible, from nurseries that send out clean stock and then insist on your nursery stock being thoroughly inspected by a competent person and, if infected, either reject it or insist upon thorough disinfection.

One way to prevent the root injuries of this louse is to plant only such apple trees as are grown upon Northern Spy roots.

If nursery stock is received with the roots "puddled," covered with mud, insist upon the mud being thoroughly washed off so as to expose the roots for inspection. This is one way nurserymen have of covering up the woolly aphis on the roots.

As we find that the lice seldom are found upon roots more than ten inches from the surface of the ground, this is a strong hint that the soil for a successful apple orchard should be deep, and that planting, cultivation, and irrigation should be so managed as to make the trees deep rooted. Set the trees rather deep, irrigate thoroughly but not often, and cultivate deeply, from the first, between the rows.

Finally, during the last half of August, before the winged lice appear, thoroughly spray for the purpose of cleaning up the lice upon the tree tops, so that the winged migrating form can not spread about to distribute the species to other trees.

NATURAL ENEMIES.

Notwithstanding the fact that this louse is heavily covered with a protective waxy secretion, it is freely preyed upon by lady-beetles (*Coccinellidae*), Syrphus flies, and Chrysopa larvae, commonly called aphis-lions or lace-wing flies. The orchardist will often notice that certain limbs or trees that were badly infested early in July may be nearly or quite freed from the lice by the

middle of August. We had an excellent illustration of what the predaceous insects can do in this way last year. Probably this insect never was so abundant in the orchards of the state as they were last year, from their first appearance in the spring until about the middle of July. About that time the enemies had become so abundant that a noticeable decrease soon became apparent and by the 10th of August it was almost impossible to find a living louse above ground. Upon the roots there was no noticeable change in the infestation. The enemies then left the trees, and the few lice that were overlooked. with a few others that migrated upward from the roots, soon began to increase in numbers, so that by the last of September the trees were showing a light infestation again. Apparently this is all easily explained. The winter of 1906-7 was very open and mild, so that plant lice of all kinds lived through unusually well and were very abundant early in the spring. As a result, there was a very abundant food supply for their enemies, which also increased with great rapidity, so that by the first of August they began to get the upper hand of the lice, and to prevent their own starvation, almost completely ate the latter from every exposed place. In the Grand Valley the greater portion of this benefit was done by the lace-winged fly (Plate I, Fig. 15), while upon the Eastern slope the lady-bettles (Plate II, Figs. 12, 13, 14, 15) were the chief benefactors, with the lace-winged flies and the Syrphus flies as efficient helpers in the good work. Specimens of a small black parasitic fly* were taken by Mr. L. C. Bragg, ovipositing in this louse at Fort Collins, August 20, 1908.

REMEDIES ABOVE GROUND.

Wherever this louse can be reached by sprays, it may be destroyed, like any other plant louse, but one important precaution is necessary, the spray must be applied with sufficient force to wet through or remove the woolly covering. This louse is then more easily killed than is the green apple aphis, which curls the leaves for protection.

There are several spray materials that may be used with success. In fact, any spray that is generally successful when used for the destruction of plant lice may be considered useful for the destruction of this insect.

KEROSENE EMULSION.

When properly made, a good kerosene emulsion has no superior, as a spray for the destruction of the woolly aphis, so far as we have been able to determine, and it penetrates the woolly covering better than most insecticides. When used in the usual strength of 1-15 (7 per cent.) oil we have always found it to be suffi-

*Aphelinus mali (Hald.), determined for us by Dr. L. O. Howard.

ciently strong. A preparation of 1-20 (5 per cent.) oil is usually successful if thoroughly applied and makes a spray of very moderate cost. Directions for the preparation of kerosene emulsion are given near the end of the bulletin. The trouble, if any, will be in obtaining a good emulsion from which the oil will not separate and collect upon the surface. To be successful use a moderately coarse and forceful spray. While we are inclined to consider a good kerosene emulsion the most efficient of all the insecticides we have used against the woolly aphis, we are aware that most orchardists have had so much trouble making it that they prefer to use something more easily prepared, even at a somewhat increased expense. Such men as B. A. Smith, F. C. Jaquette, Joseph Cornetto, E. M. Cheedle, W. K. Haines, and others in the Grand Valley, have used the emulsion with the best of results.

SCALECIDE AND OTHER MISCIBLE OILS.

There are upon the market a number of so-called miscible, or soluble, oils which, when put into water, break up into very fine particles and form a milky white emulsion. These, like kerosene emulsion, make a very good and efficient spray for lice if they do not separate to form a film of pure oil on top. The only preparation of this kind that we have used at all extensively is Scalecide. When used as strong as 3 to 4 per cent. oil we have found it very effectual. Apparently the soluble oils have to be used with more care than kerosene emulsion on account of their liability to injure foliage when too strong.

SOAPS.

In our experiments for several years past some of the standard whale-oil or tree soaps have given very satisfactory results, but, for some reason, the orchardists have not seemed to be as successful with the soaps they have used. We have used chiefly the brands sold as Good's Whale-oil soap, and Bowker's Tree-Soap, and 1 pound to 8 gallons of water has usually been sufficiently strong. The warmer these soaps can be when applied, the better. We believe the soaps can be purchased so as to be among the cheapest of spray materials, and if anyone has been using a brand that has given him success, we see no reason why he should make a change. Mr. A. L. Roberts, of Paonia, reported to us last year that he completely cleaned the woolly and green apple lice out of his orchard by thoroughly spraying with 13 pounds of whale-oil soap and 1 gallon of Black Leaf to each tank of 220 gallons of water.

"BLACK LEAF."

The Kentucky Tobacco Product Company, of Louisville, Kentucky, manufactures a tobacco extract which they sell under the

above trade name and which has become very popular among the orchardists of Delta County as a spray for all plant lice in their orchards. Purchased in car load lots, it is one of the cheapest, and most easily prepared, of all spray materials used, and has given remarkable satisfaction, and in our experiments it has given splendid results. Aside from the fact that it does not penetrate the woolly covering of the lice quite so readily as the kerosene emulsion, we are inclined to place it about on a par with that insecticide in its killing effects. When this, or any other spray, is used, special care must be taken to throw the spray from all directions and under high pressure, 140 to 180 pounds, if possible, to get best results. The manufacturers write us that they take great pains to put out a uniform product of Black Leaf so far as the nicotine content is concerned, and that this is the only ingredient that it contains that has any special insecticidal value. This being the case, if the manufacturers keep up the present standard of quality in this dip, we predict that it will come into very general use for the destruction of all aphids upon out-of-door plants.

While the orchardists have been using Black Leaf, in most cases, in the proportion of 1 gallon to 65 gallons of water, we have found in our experiments, where we know that thorough treatments have been made, that 1 gallon to 75 gallons of the watery mixture is very uniformly successful in killing all the lice, and 1 to 100 (a 1 per cent. mixture) seldom fails to give excellent results.

It is a good plan for the orchardist to treat a few trees with varying strengths of his mixture a day or two before taking up his spraying in an extensive way, and note carefully the results. In this way he may save many dollars, either from using the insecticide in strengths that are unnecessarily strong, or by throwing away a large amount of time and material in the application of a spray that is too weak to give satisfactory results.

TOBACCO DECOCTIONS.

Some may prefer to make their own tobacco sprays, either by using tobacco stems, tobacco dust, or whole-leaf tobacco. While fruit growers do not report very uniform results from their own tobacco preparations, our experience has been different. When we have steeped tobacco stems, or tobacco dust, in water in the proportion of 1 pound to two gallons, or the whole-leaf tobacco in the proportion of a pound to four gallons of water, we have been very uniformly successful in getting a decoction that would kill the lice. See directions for preparing tobacco decoction near the end of this bulletin.

Mr. W. S. Coburn, President of the Colorado State Board of

Horticulture, tells us that he has had excellent success by using tobacco of his own raising in the proportion of 1 pound to 6 gallons of water after steeping for a full hour and then applying warm.

LIME-SULFUR SPRAYS.

Lime-sulfur sprays used during the summer, when the lice have a wooly covering, have not proven satisfactory in our experience. For early spring spraying, see below.

Chloroleum, potash lye, and strong lime washes have also been tried without marked beneficial results.

LATE WINTER OR EARLY SPRING APPLICATIONS.

So far, the remedies mentioned have been for summer treatments, when the bodies of the lice are more or less covered with the waxy secretion. We believe the best time to get results in the treatment of this louse is late in the winter or early in spring before the buds open. This is not because the lice get protection from the opening buds, but because by the time the buds have opened, the lice have their bodies more or less covered by the waxy secretions that protect them to some extent from the effects of the insecticides.

Orchards in the Grand Valley treated early in the spring of 1907 for the destruction of the eggs of the green apple aphis were partially freed from the woolly aphis also.

We have no doubt but what kerosene emulsion, the soluble oil sprays, the tobacco sprays and the whale-oil soaps, could be used successfully as early spring sprays for the destruction of the overwinter lice upon the tree top, though we have not tested them in that way. As they are not as successful for the destruction of the eggs of the green apple aphis, and as the orchardist is likely to want to destroy both of these lice at the same time, if possible, it is probable that the lime-sulfur sprays will become most popular for early spring applications.

To get best results on the woolly aphis the spring application should be made fully a week or ten days before the apple buds begin to open at all, and the trunk and crown of the tree should be thoroughly drenched. Then, as a final act for best results, put tanglefoot bands about the trunks of the trees so that the lice at the roots cannot migrate to the top. For the application of these bands, see next paragraph.

TANGLEFOOT BANDS.

In the experiments upon the Western slope in particular, large numbers of Tanglefoot bands have been used. This material is put out by the O. & W. Thum Co., Grand Rapids, Michigan, and is

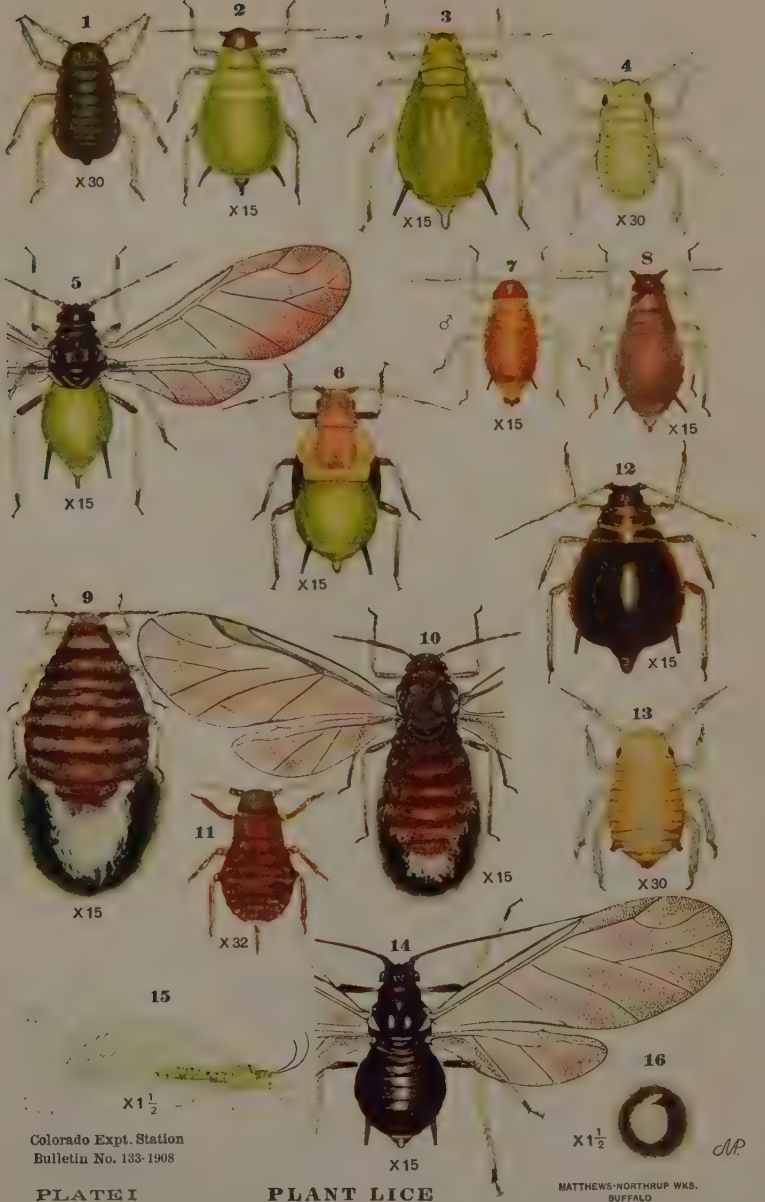

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PLATE I

PLANT LICE

MATTHEWS-NORTHRUP WKS.
BUFFALO

similar to the sticky material put upon the Tanglefoot Fly-paper. When at all abundant upon the trees, the newly-born lice are much inclined to travel about, and it is often astonishing to see the number of lice that will be captured in these bands. On the 7th of June, 1907, it was estimated that bands that had been on since the preceding fall had as many as 100,000 lice each in many cases. The bands remain fresh for several months and may be quickly freshened by rubbing a paddle over them, when they become filled with insects and dirt.

Mr. Weldon, field entomologist, reports these bands doing harm to trees, where they have been on for more than a year. The Tanglefoot was placed directly upon the bark, but it would be safer to put a band of stout paper around the trunk and then put the Tanglefoot upon that. To make certain that no lice should pass under the band, a light band of the cheapest cotton batting under the paper would be advisable. This band, in connection with the spring spraying mentioned above, we believe to be the surest method of freeing the tree tops of woolly aphis.

MOUNDING AND CULTIVATING.

The woolly aphis is not a burrowing insect in any true sense of the word. The lice that come down the trees get into the ground by way of the cracks or other openings in the soil that are large enough to allow them to enter. The lice that sometimes infest distant roots do not get to them by crawling there all the way from the crown of the tree, but they get down to them directly from the surface above. So far as possible, the descending overwinter lice congregate about the crown of the tree where they are able to get below the surface in the large cracks between the trunk and the earth. The migration, both to and from the roots, can be somewhat, often very largely, prevented by cultivating the surface of the soil and by stirring and compacting and even slightly mounding the earth about the crown of the tree and by re-stirring this earth when it becomes compacted after a rain or an irrigation.

TRIMMING.

When the lice become very abundant upon water sprouts and suckers, something can be done to lessen the number by thoroughly cutting out these growths, and a thorough thinning of the top so that plenty of sunlight can enter, has been noticed to lessen the number of lice which find the most congenial locations for their development in dense shade and upon the north side of the limbs, at least in sunny Colorado.

TREATMENT BELOW GROUND.

The treatment below ground is all aimed at the lice that are

within three feet of the crown of the tree and within one foot of the surface. It should also be remembered that the same substances that will kill the lice above ground will also kill them below, if they can only be put in contact with the lice. The orchardist should be cautious, also, not to accumulate in the soil, about the crowns of his trees, substances that are likely, either presently or after years of repetition, to do his trees an injury.

EXPERIMENTS IN GRAND VALLEY.

For many years tobacco, in the form of dry dust, stems or leaves, has been considered the best known remedy for this louse. Soapy solutions have also been thought of some value. In Bulletin 23 of the Georgia Experiment Station (1907), Professor R. I. Smith, reports far better success with kerosene emulsions than with tobacco or soaps for the destruction of the apple woolly aphis upon roots.

A rather extensive series of experiments for the purpose of testing substances that seemed to offer some promise of good results were carried through in irrigated orchards of the Grand Valley in Colorado, a summary of which is given in the table on the following page.

The authors are under special obligations to the men who kindly offered their trees for the experiments and in other ways aided in carrying on the work.

THE APPLICATIONS AND THEIR RESULTS

The experiments were begun in the fall of 1906 and the winter following. The materials used upon the roots were kerosene emulsion, Scalecide, Chloroleum, Black Leaf Dip, tobacco dust, tobacco dust decoction, tobacco stems, tobacco stem decoction, quick lime, lime-sulfur mixture, Rex lime-sulfur, Adams' lime-sulfur, whale-oil soap, and carbon bisulfide, as shown in the table. Other tests were also made upon the roots which are not scheduled.

Before making the applications, the earth was removed over the main roots to a depth of about 6 inches, and for a distance of about 2 feet upon all sides, of each tree. One man on an average would expose the roots of about 100 trees a day. Into these dirt basins, which varied some in depth and diameter, with the size and depth of the roots of the trees, the liquids were forcefully sprayed so as to well drench the exposed portions. Both the treated trees and the checks were given a rating of 1 to 4 as to degree of infestation, so as to be able to make fair comparisons in determining results. The liquid applications were then forcefully sprayed upon the roots in these basins until two or three gallons had been applied, and when the liquid had nearly or quite soaked into the

EXPERIMENTS FOR THE DESTRUCTION OF THE WOOLY APPLE APHIS

ORCHARD OF	INSECTICIDES	STRENGTH	TREATED	DATE USED	EXAMINED
P. Nissen	Lime and Sulfur	15, 15, 50	Tops and Roots		Nov. 19, '06
	Chloroleum	1 to 40	Tops	November 7, 1906	Nov. 23, '06
	"	1 to 50	Tops and Roots		Nov. 28, '06
	Scalecide	5% oil	" "		Jan. 11, '07
	Tobacco Dust	2, 4, 5, 6 and 8 lbs.	Roots	Nov. 23-28, 1906	Mar. 15, '07
	Tobacco Stems	2, 4, 5, 6 and 8 lbs.	"		Mar. 25, '07
	Quick Lime	10 and 20 lbs.	"		June 6,07
	Rex	1 to 11	Tops	Mar. 25, '07	
	Ker. Emulsion	7% oil	As Bands		
	Tanglefoot				
I. D. Smith	Ker. Emulsion	22.2% oil	Tops	December 18, 1906	Summer, '06
	" "	16.6% oil	"		Jan. '07
	" "	13.3% oil	"		
	Scalecide	1 to 19 (5%)	"	June as bands	
	Tanglefoot				
E. Turpen	Rex L. S.	1 to 8 with lime	Tops	March 2-22, 1907	April 26 1907
	Adams L. S.	" " "	"		
	"	1 to 8 with no lime	"		
	Lime and Sulfur	1—1—2	"		
	" "	1 -1 3	"		
	" "	1—1—4	"		
M. Cheedle	Rex L. S.	1 to 8 no lime	Tops	March, 1907	June 5, '07
	Tobacco stem Decoction	1 lb. to 1 gal.	"	Apr. 2-6, '07	Aug. 22, '07
					June 5, '07
	Ker. Emulsion	7% oil	"	Mar. 1 to Apr. 6	Aug. 22. '07
C. Jaquette	Whale-oil Soap	1 lb.—4 gal.	Tops	April 2	
	Ker. Emulsion	9.4% oil	"	April 2	
	Ker. Emulsion	6% oil	Roots and Tops	April 9	April 9 to June 7
	Ker. Emulsion	6% oil	Roots	June 7	June 20
	Checks				
	Carbon Bisulfid	3 oz. to tree	"	April 11	May 16
A. Smith	Lime Sulfur		Tops		
	Rex & Adams				
	Tobacco Dust Decoction	1 lb.—2 gall.	"		
	Tobacco Dust Decoction	1 lb.—3 gall	"		
	Ker. Emulsion	5% oil	"	Mar. 2 to 6	Mar. & May
	" "	6% oil	"	Mar. 2 to 6	" "
	" "	7% oil	"	May	
Cornetto	Ker. Emulsion	3, 5, 6, 7, 10, 15 20, 33, and 50% oil	Roots	June 26 to July 2	July 22
	" "	5 and 6% oil	Tops		August 22 and Sept. 13
	Black Leaf	1 to 50	Roots		
	" "	1 to 66	"		
	" "	1 to 75	"		
	Tobacco Dust	1 lb. to 1 gal., 1 lb. to 3 gal., 1 lb. to 5	"		
	Tobacco Stems	2 lbs,—1 gal,	Roots		
	" "	1 lb.—1 gal.			
	" "	1 lb.—3 gal.			
	" "	1 lb.—5 gal.			
	Tobacco Stems	6 lbs. per tree	Roots		
	Scalecide	1—40, 1—60, 1—50	Roots		

ground, the basin was filled again and the earth banked well about the trees. In hard, compact soils it is best to irrigate a few days prior to making the treatment so as to loosen the soil and lessen the labor of excavating about the trees.

Summing up the results to September, 1907, it may be said, that practically all strengths of kerosene emulsion (3 per cent. to 50 per cent.), killed the lice well when the roots had been well treated. Where less than 6 per cent. of oil was used, the odor of kerosene soon disappeared and reinfestation soon took place by the lice that migrated downward from the top. Where 7, 10 or 15 per cent. of oil was used, the effect was still more lasting, and the 20, 33 and 50 per cent. treatments gave practically perfect freedom from lice about the crown and roots throughout the season.

The trees in the above experiment were examined later by Mr. George P. Weldon, who reported upon the effects of the various applications, as follows:

EXPERIMENTS IN THE ORCHARD OF J. CORNETTO.

"Grand Junction, Colorado, July 10-11, '08.

"I am disappointed to find that the wooly aphis is very abundant on all of the roots of treated, as well as check trees, in the experiment, even where a 50 per cent. kerosene emulsion was used. Where this strength was applied, the odor of the soil is still very pronounced when then earth is stirred, and the trees show severe injury from the application. The roots are being killed and the leaves are wilting, and it is probable that the trees will soon die. A comparison of the treated trees with the check tress does not indicate that any benefit from the various treatments has continued to the present time. Even where the 50 per cent. oil was used, the lice are as abundant as upon the check trees in the experiment. There are almost no lice above ground upon any of the trees at this time. With the exception of the 50 per cent. kerosene emulsion treatment, none of the applications seem to have done any harm to the trees.

"Roots treated with tobacco dust, even where eight pounds to a tree are used, do not show any indications of benefit from the application now.

"In the Jacquette orchard I find that the Tanglefoot bands that have been on for two seasons are doing serious injury to the bark of the trees, especially upon the south side."

Some orchardists have reported to us that they believe they have had trees sickened and even killed from the kerosene emulsion that accumulated about the roots at spraying time, and one or two have reported applying kerosene emulsion to the roots of apple trees during the winter for the destruction of the woolly aphis and that the trees all died after a few years. So, while we know that kerosene emulsion is a very effectual destroying agent for woolly aphis on roots, we are inclined to advise those who use it to be cautious and to keep a close watch of their trees and stop farther treatments as soon as any signs of injury appear. It might be well to select a few trees that one does not care very much for and

treat them somewhat severely with the thought that so long as they show no injury, it is probably safe to treat others more lightly.

CARBON BISULFID.

This insecticide has often been reported successful against this insect upon the roots.

A splendid opportunity was afforded to observe its results in the 20-acre orchard of Mr. F. D. Barney, where about 200 pounds of the liquid was used on 12-year-old apple trees. The treatment was begun on April 11, 1907, and was continued several weeks before being completed.

At the beginning of the treatment a trench 4 or 5 inches deep was dug encircling the tree and about 3 to 4 feet in diamater. Three ounces of liquid carbon bisulfid were poured into the bottom of the trench, and moist earth thrown quickly in and packed down with the shovel. This method did not seem successful, and another process was substituted. A shovel was thrust deeply into the ground about 18 in. to 2 ft. from the base of the tree with the blade broadside to the tree. The handle was then tipped forward and the carbon bisulfid poured in at the center of the opening at the back of the shovel. The shovel was then withdrawn and the earth packed upon the spot treated. Care was taken not to pour the liquid directly upon the roots. From three to six holes were treated in this way about each tree and about three ounces of the liquid used. At this rate the cost of the material did not amount to as much as 3 cents per tree.

Observations on May 16th showed some good accomplished, especially where the infested roots had been near to the points where the bisulfid had been poured, but there were many living lice still remaining about the crowns of the trees. The soil at time of treatment was loose, friable and moist, but not wet. The results seemed to indicate that such a treatment would be profitable in cases of severe root infestation, but not as effective as kerosene emulsions or tobacco decoction applied directly to the exposed tree roots.

Tobacco Dust and Stems have not given very satisfactory results in our experiments nor with most of the orchardists who have tried them. Where 5 or 6 pounds to a tree has been used directly upon the exposed roots and about the crown, followed by a thorough irrigation about the trees, we have had reports of good and poor results, even when thoroughly irrigated at once to soak the juice down about the roots, so we do not think tobacco dust or stems can be relied upon for satisfactory results.

Tobacco Decoctions in which 2 pounds of stems, or dust, or 1 pound of whole leaf tobacco was used to each 3 gallons of water and

forcefully sprayed upon the exposed roots gave fairly good results, but these were not equal in their killing and repelling effects to a 10 or 15 per cent kerosene emulsion.

Black Leaf Dip used in the proportion of 1 gallon in 65 gallons of water gave results similar to the preceding.

Scalecide used 1 to 40, 1 to 50 and 1 to 60 in water killed the lice fairly well, but had very little repelling effect afterwards.

Soaps used for root treatment were of doubtful benefit.

Some Wholly Unsuccessful Substances were "Chloroleum," lump lime (10 to 20 pounds to a tree), potash lye, wood ashes, salt and flooding with water for several hours.

ROOT TREATMENT OF NURSERY STOCK

Apparently none of the inspection laws have prevented, though they have greatly lessened, the shipment of trees infested with woolly aphis. It is commonly recommended to dip or fumigate such trees to destroy the lice.

We have found the ordinary dipping process quite ineffectual in cases of severe infestations on account of the protection afforded by the woolly secretions, but we have had perfect success by untying the bundles and forcefully spraying the trees upon roots and tops with kerosene emulsion (7 to 10 per cent oil), or one of the tobacco or soap preparations used for top treatment. *Make the spray forceful and drench all parts.* It requires but little time or material to treat thousands of trees. Where this work is to be done on a large scale, a water tight spraying surface or pan could easily be arranged with a drainage tank so that the same spray material could be used over and over.

Dipping for 6 seconds in water heated to 140 degrees Far., and fumigating for 40 minutes in hydrocyanic acid gas we have also found efficient remedies for the destruction of this louse on nursery trees.

CONCLUSIONS AS TO BEST METHODS OF TREATMENT

Just before the buds open in the spring, spray very thoroughly with a 7 per cent kerosene emulsion, Black Leaf dip 1 pound to 60 gallons of water (or some other strong tobacco decoction), or a good whale-oil soap, 1 pound to 6 gallons of water. Spray the entire trunk and also the ground about the crown of the tree. Immediately after treatment apply a Tanglefoot band over cotton so as to prevent the upward migration. If the lice become very numerous at any time upon the tops, spray them forcefully with the 7 per cent emulsion, or Black Leaf, 1 part in 70 parts of water.

Root treatments are temporary in their effects. When the roots become very badly infested, treat as above described with 10 per cent kerosene emulsion, Black Leaf dip (1 to 50), 2 to 3 gal-

lons to a tree, or, if the soil is quite open and porous, carbon bisulfid*.

THE GREEN APPLE APHIS

(*Aphis pomi DeGeer.*)

Plate I, Figs. 1 to 8, and Plate III, Fig. 5.

This insect was first described in Europe by DeGeer in 1773 and two years later was described by Fabrecius as *Aphis mali*. It is not known when it first appeared in America, but Mr. Theodore Pergande has been quoted as saying that he first saw it here in 1897. In 1900 Dr. J. B. Smith gave excellent descriptions of this louse in its different forms with an account of its habits in Bull. 143 of the New Jersey Experiment Station. This seems to be the first published account of what we are calling the "green apple aphis" in this country. Now it is known to be very generally distributed throughout the country, being readily carried upon nursery stock in the egg stage.

The dry climate of Colorado seems favorable for the development of this louse and its natural enemies have not been sufficient in recent years to keep it in check without the aid of spray pumps and insecticides.

Sanderson's statement* that *A. pomi*, "is, however, by no means as common as *A. fitchii*" (really *avenae*), surely does not apply at all to Colorado, where the latter species, in all the apple growing sections, is a comparatively rare insect and one that we have never found occuring in abundance upon a single tree. *A. pomi* is one of our very worst orchard enemies, and is, also, the species most commonly brought into the state in the egg stage, upon nursery stock.

FOOD PLANTS

This louse spends its entire life cycle upon the apple and pear trees and does not, so far as we have been able to observe, leave these trees during a portion of the summer to feed upon other plants, as so often occurs with other species. So one need never fear that this insect will migrate from the apple and pear trees to other fruits or vegetables, and it is equally true that it will not migrate to the apple and pear trees from weeds or vegetables, as it does not infest them.

Besides the apple and pear, this aphis also attacks the hawthorn, the quince and the flowering crab, but the cultivated apple seems to be its favorite food plant. Among the apple trees it has its preference. The Missouri Pippin seems to be its first choice

* Carbon bisulfid may be procured in quantity from Edward R. Taylor, Penn Yan, New York.

* Thirteenth Ann. Rep. Del. Ex. Sta., p. 131, 1901.

while Rome Beauty, Black Twig, Ben Davis and a few others are close seconds, and the Northern Spy is scarcely attacked at all.

This insect gets its food by inserting its beak and sucking the sap from either the leaves or the rapidly growing, softer and more tender twigs. For this reason rapidly growing young trees, grafts, and water sprouts are worst infested. When upon the foliage, this louse feeds, for the most part, upon the under side of the leaves, which curl in such a way as to give it considerable protection from the direct rays of the sun, and from sprays that are not used with force and thoroughness.

LIFE HISTORY

Like most insects, this green aphis has very definite life habits. Probably we cannot do better than to begin with the egg and follow it through its different stages of development.

THE EGGS

The winter is past entirely in the egg stage upon the twigs of the trees that were infested the previous fall.

Many lice select the axils of buds and rough places in the bark for the deposition of their eggs, but this one seems to prefer the free surface of the rapidly growing shoots. When the lice are abundant, the water sprouts, in particular, are often fairly blackened with eggs (see Plate III, Figure 5).

When first deposited, the eggs are light green in color, but soon become shining black from the action of the sunlight upon them. They are long oval in shape and are just large enough to be plainly seen by one who has good eye sight. By actual measurement it would require 40 of these eggs, placed end to end, to extend one inch.

Very few of the eggs ever hatch, according to our observations. On the eastern slope, at least, it seems doubtful if more than one per cent hatch in average years. Even this small percentage of the eggs hatching is sufficient with the rapid rate of increase to enable this insect to become destructively abundant before fall. When the time arrives for the little louse to come from its winter quarters, the shell splits longitudinally upon the upper surface near one end and the prisoner, with much writhing and kicking works itself out. No definite date can be fixed for the hatching. The first lice were found emerging in 1907 at Palisades just as the first apricot blossoms were opening. At that time the apple blossoms were but little swollen. In a general way it may be said that the lice begin to hatch a little before the apple buds show any green and continue to hatch for two or three weeks, depending upon whether the weather is warm or cold most of the time.

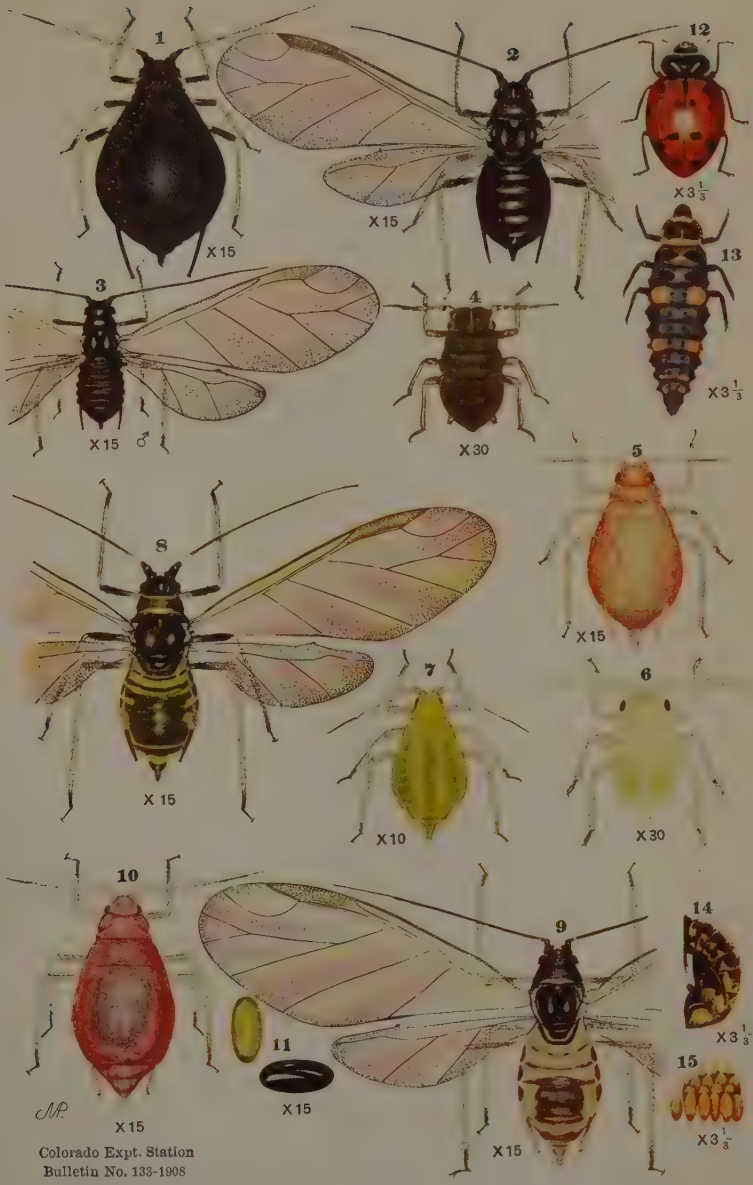

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PLATE II

PLANT LICE

M.-N. WORKS
BUFFALO

THE STEM MOTHERS

Plate I, Figs. 1 and 2.

The lice hatching from the eggs in the spring are all females, and are called "stem mothers" because from them spring all the succeeding brood of the year. No other lice of the year are quite like these that come from the eggs. The little louse upon first hatching is very dark green in color while other young of the year are very light yellowish green (Plate 1, Figs. 1 and 4). If the buds are not yet open, the stem mothers are able to live a few days for the buds to swell enough to enable them to insert their beaks into the tender tissue of the young leaves for their first meal. As soon as the buds open enough to make it possible, the little lice work their way down into the folds of the opening leaves where they are protected from the cold and from the lady beetles and other insect enemies and the death dealing sprays of the orchardist. In about two or three weeks, if the weather is warm, our stem-mother will have attained full development and will begin to give birth to living young at the rate of 3 or 4, to 10 or 12 a day. During their whole life these stem-mothers differ in appearance from any of the later broods of the year. They never get wings, are of a rather dark green color with a conspicuously dark colored head; the antennae are shorter and usually six, though they may be seven jointed; the cornicles are rather short and black and the cauda or tail is also black. The stem-mother is usually a little smaller than her grown children and grand children, measuring only .06 of an inch (1.50 mm.) in length when fully grown. (See Plate I, Fig. 2.)

SECOND GENERATION

As soon as the stem mother becomes fully grown, she begins to give birth to living young which constitute the second generation. Each female may deposit as many as 75 to 100 young during a period of two or three weeks and then she dies. These young are all female which, like their parent, are capable of giving birth to living young. We have found a very small percentage of the second generation getting wings. So the winged lice may begin to scatter from tree to tree and orchard to orchard at Grand Junction about May 10th, and at Fort Collins about June 1st. It is not until the 3rd. generation that the winged lice appear in large numbers, so that the migration of winged lice is not usually noticed until about the first week in June in the warmer orchard sections in Colorado, and two or three weeks later in the colder portions. After mid summer the winged lice begin to grow fewer in numbers and disappear entirely about September 1st.

WINGLESS FEMALE OF SUMMER GENERATIONS

Plate I, Fig. 3.

The summer wingless females (all after the stem mother) when fully grown, are a trifle larger than the first generation, are yellowish green in color, have 7 joints to the antennae, both antennae and cornicles are longer than in the stem mother, and the cornicles, cauda and the greater portion of the antennae are black. These females continue until late fall and are very prolific, giving birth to living young.

WINGED FEMALES

Plate I, Fig. 5.

The winged females also give birth to living young lice. They fly about to other trees and so establish many new colonies, some of which will be likely for a time to escape being found by their enemies.

These winged migrants are not numerous until the third brood and they continue to appear in considerable numbers until about the last of August, when they soon disappear, and true sexual males and egg laying females take their places.

About the first of September* males and egg-laying females begin to appear. The males and females pair and the latter begin to lay eggs about the middle of September and continue to do so until killed by severe freezes.

MALES

Plate I, Fig. 7.

The male is wingless, is yellowish or rusty brown in color, and is much smaller than any other adult lice of the year.

EGG-LAYING FEMALE

Plate I, Fig. 8.

The egg-laying female is considerably larger than the male, but is smaller than the other female lice of the year and is yellowish green in general color with considerable variation.

NATURAL ENEMIES

This louse is attacked by about the same natural enemies as the wooll aphis. The Lady Beetles seem to us to be the most efficient as destroyers of it though the syrphus flies and aphis lions (lace-wing flies) also kill great numbers. They are almost never attacked by parasites, in fact the only parasitic attacks that we have seen have been by a minute Chalcid (*Alphalinus mali*)* that causes the lice to change to a deep coal black while they retain their natural size and shape.

* Our earliest date for males at Fort Collins is September 4.
* Determined for me by Dr. L. O. Howard.

Sometimes the orchardist thinks that ants are destroying the ce upon his trees. This is never the case. The ants visit the lice or their sweet secretions and are careful not to harm them and ney ever stand ready to drive away many of the enemies of the ce.

REMEDIES

The remedies to use against this insect, from the time the uds open in the spring until the leaves drop in the fall, are the ame as those given for the woolly aphis above ground. Kerosene mulsions that is one-fifteenth oil and Black Leaf dip, 1 part in 70 arts of water, are the two most favored sprays at the preent time n Colorado.

WINTER AND EARLY SPRING SPRAYS

For several reasons, late winter and early spring are most avorable for the destruction of the green apple aphis. The orchard- st usually has more time then in which to do the work; the foliage eing off, it requires less pains, time and material to make a thor- ugh treatment, and by spraying early one avoids destroying the lant louse enemies which are killed along with the lice in summer praying. If the work is well done in early spring, the trees should e free from lice until the winged migrants have flown in from eighboring orchards and established their colonies upon the trees. Such orchards will seldom become seriously infested before July, f they are at all during the summer, so they are sure to make their rowth unhindered and will seldom fail to mature their crop in ood condition.

Professor Aldrich seems to have been the first to report suc- ess from winter treatment of orchards for the destruction of the ggs of plant lice.* He reported very satisfactory results from the se of lime-sulfur sprays made by both the 1-1-2 and the 1-1-4 ormulas (1 lb. lime, 1 lb. sulfur, and 2 gallons water; and 1 lb. ime, 1 lb. sulfur and 4 gallons water), but did not succeed in lestroying the eggs with emulsions of kerosene oil.

In our experiments for the destruction of eggs we have found he oil emulsions useless, killing only in very high strengths, if at ll.

The treatments that we have found quite successful for the lestruction of eggs are:

Lime-Sulfur mixture, 1-1-2 formula, sp. grav. 1065.
Lime-Sulfur mixture, 1-1-3 formula, sp. grav. 1045.
Rex Lime-Sulfur, 1-8 strength, sp. grav. 1055.
Rex Lime-Sulfur, 1-4 strength, sp. grav. 1080.
Black Leaf, 4 per cent strength.

* Bull. 40, Idaho Exp. Sta., 1904.

Black Leaf, 3 per cent strength.
Black Leaf, 2 1-2 per cent strength (a little weak.)

THE CLOVER APHIS

(*Aphis bakeri* Cowen)

Plate III, Figs. 1, 2.

This louse was described by Mr. Cowen in Bull. 31 of this station in 1895. *Aphis cephalicola* Cowen, described from heads of white clover, is the same species.

On April 13, of this year we found a red stem-mother of some unknwn aphis rather common, and in many cases fully grown, upon the buds of apple and pear trees about Delta, Colorado. The color varied from a dark green streaked and mottled with red to a deep dark red, with cornicles very short and pale yellow throughout. At this time the apple buds were just beginning to open and peach trees were nearly in full bloom. It seems probable that these stem-mothers must have hatched fully two weeks prior to this date to have become fully grown. The green apple aphis (*A. pomi*) at this time was just hatching and none were found that were more than half grown.

The identity of the louse was not suspected until the department artist, Miss M. A. Palmer, suggested that the second brood lice looked like her drawings of the clover louse, *A. bakeri*. A careful comparison indicated that the two forms were identical except for a little difference in color. This second generation (the offspring of the stem mothers) were light green or yellowish green in color, while *bakeri*, upon clover, is pink or yellowish. A large pale orange blotch surrounding each cornicle is also quite characteristic. Sprigs of apple infested with this louse were put in a cage with red clover and the lice in all stages readily adopted the clover as their food plant. Later the pink form was also found upon apple and crabapple (*Crategus sp.*) and no doubt was left that all were one species with varations in color.

FOOD PLANTS AND LIFE HISTORY

Summing up the life habits of this insect from all the observations we have upon it in the records of the Experiment Station for the past nine years we conclude as follows:

The clover aphis, *A. bakeri*, infests the cultivated and sweet clovers and alfalfa throughout the warmer part of the year where, apparently, it never occurs in the oviparious form nor as eggs. In the fall, a portion of the winged lice migrate to apple and pear trees where eggs* are deposited to live over winter and hatch into the red stem mothers the following spring. The descendants of

* Oviparous females and eggs we have not seen with certainty.

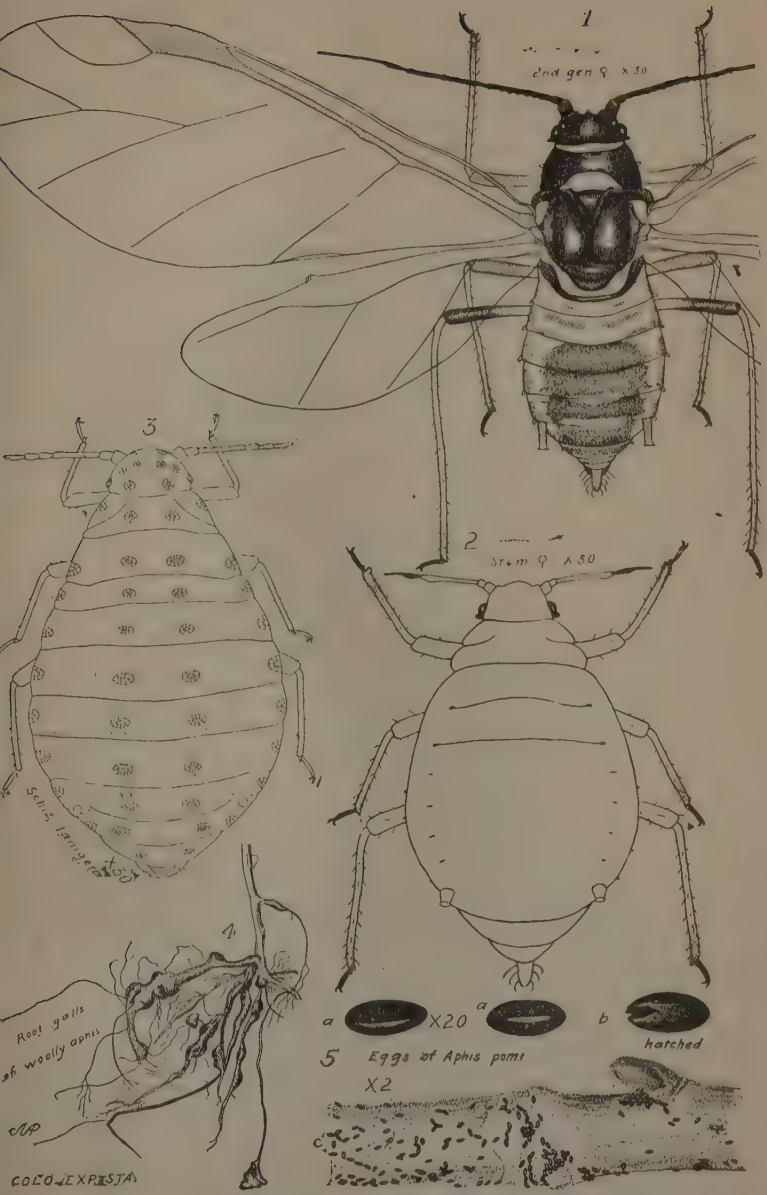

PLATE III. Fig. 1. Winged viviparious female of **Aphis bakeri;** 2. Stem mother of **Aphis bakeri;** 3. Wingless viviparious female of **Schizoneura lanigera** showing wax glands; 4. Root galls of woolly aphis of the apple; 5. Eggs of the green apple aphis **(Aphis pomi),** a. Eggs much enlarged; b. Egg shell after the louse had hatched; c. Apple twig with eggs upon it. Figures 1, 2, and 3 are enlarged 30 diameters; figure 5, a. and b, enlarged 20 diameters, c. enlarged 2 diameters.

M. A. PALMER, Artist.

these stem females begin in the second generation to get wings and by the middle of June nearly all have left the trees and gone back to the clovers,** though some remain on the apple all summer. In the fall, many of the lice continue upon the clovers, going down close to the ground as cold weather comes on, and if the winter is not very severe, many will survive and continue to live and increase upon these plants throughout the year. Mr. L. C. Bragg has carried this louse through the winter in the laboratory upon red clover without trouble, but no eggs or egg-laying females were obtained.

So far as our observations have gone, this louse ranks next to the green apple aphis (*Aphis pomi*) in numbers as a leaf infesting species of the apple. Mr. George P. Weldon reports it as having a tendency to accumulate in the apple blossoms, but we can hardly consider it a serious pest as yet in Colorado orchards.

Remedies the same as for the green apple aphis except that the application to kill the stem-mothers should be applied earlier, fully a week before the leaf buds begin to open at all.

THE EUROPEAN GRAIN APHIS

(*Aphis* (*Siphocoryne*) *avenae* Fab.)

This louse was found in a few apple orchards in the Grand Valley in 1907, and during the spring and early summer of 1908 it was observed in small numbers upon fruit spurs and succulent sprouts upon the trunks and large limbs of apple, pear and quince, in the orchards about Delta, Paonia, Montrose and Rockyford. Mr. Weldon reported it on apple at Montrose as late as June 18. In no case has it been found in sufficient numbers to do appreciable harm. In our experience the apple has been the preferred tree, and colonies upon the pear and quince have been rare.

This louse is readily separated from any of the other species here mentioned by the alternating transverse stripes of light and of dark green that cross the body above, by the light colored cornicles with black tips that are present in both young and adult forms, and by the very short second fork in the third transverse vein of the fore wing of the winged forms. It curls the leaves in a manner similar to the green apple aphis, *Aphis pomi*.

This insect was first described in Europe by Fab., as a grain louse, and it was not until 1894 that Mr. Theodore Pergande* discovered that it also feeds upon the leaves of apple trees during a portion of the year. It is said to be the most abundant apple leaf aphis of the eastern states.

** July 8, and again Aug. 16, '08, several colonies were found on apple about Fort Collins. Mr. Weldon reported this louse on apple at Delta, Colo., July 12, '08.

* Bull. 44, Div. of Entomology, U. S. Dept. of Agr.

LIFE HISTORY

The lice that first appear in the spring, the stem-mothers, hatch quite early, before the buds begin to open at all, from little shining black eggs that were deposited upon the bark of the twigs the preceding fall as in case of the common apple aphis. These stem-mothers are fully as forward as those of the clover aphis. They were mature and depositing young of the second generation in the orchards about Delta as early as April 14th this year.

The stem-mothers are rather deep green in general color with the head and tail ends of the body lightest in color, and the green may or may not take the form of lighter and darker transverse stripes. They do not acquire wings.

These first lice give birth to young for two or three weeks, or somewhat longer, and then die. Some of these second generation lice get wings and leave the trees. What lice are left produce a third generation which more largely become winged and leave, according to Pergande, to go upon certain grasses, especially oats, wheat, barley, and rye, where they continue to increase in numbers until late in the summer or early in the fall, and the winged migrants leave the grains and grasses again and return to the trees. Here they probably give birth to the true males and females, the latter of which deposit the eggs to remain over winter and hatch the stem-mothers to start the complex round of development for another year. (We have not yet traced the fall stages, nor have we been able to colonize it upon the grasses from the apple.)

We have not prepared technical drawings for this louse*

THE ROSY APPLE APHIS*

(*Aphis pyri* Boyer.)

A rosy tinted aphis of doubtful determination appeared in con-

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* For illustrations of this louse see Pergande's figures, Bull. 44, Bureau of Ent.; also Sanderson's 13th Rep. Del. Exp. Sta., p. 139.

* This seems undoubtedly to be the louse that Sanderson described and figured in the 13th Annual Report of the Delaware Experiment Station (1901), as **Aphis sorbi.** Quaintance, Circular 81, Bureau of Entomology (1907), considers this to be **Aphis malifolii** Fitch, but Fitch describes this louse as being "of a shining black color throughout," and also states that "the legs are entirely black." None of the lice we have taken fill these requirements. Specimens of **Aphis sorbi** from Europe sent by Dr. Cholodkovsky and taken by him from **Sorbus aucuparia,** the original food plant of this species, fit well into Kaltenbach's description, and are doubtless that species. While the Colorado material possesses the four dorsal spines in front of the cauda and has the general color markings of **sorbi,** the dorsal tubercles are smaller and the lateral tubercles of the abdomen and thorax are much weaker. The larvae and pupae sent by Dr. Cholodkovsky have the cornicles unusually large and strongly tapering, while in our material the cornicles are not excessive in size. On the whole, our Colorado louse seems more nearly to correspond to the descriptions and figures of **Aphis pyri** Boyer, as given by Koch, and also by Buckton, and these descriptions and figures seem also to correspond very well with the **characteri-**

siderable numbers upon individual trees in some of the orchards of the Grand Valley last year. It attacks the leaves, causing them to curl exactly as in the case of the green apple aphis, but it is readily distinguished from that species by the pink color, especially of the wingless forms, and by the slight covering of a white powdery material. The winged lice have their head and thorax nearly black, but the abdomen is yellowish or rusty brown about the margins and dark brown over the middle portion, and never green or black as in the other species mentioned upon the apple. We are calling this, rather doubtfully, *Aphis pyri Boyer*. Remedies the same as for the green apple aphis (*Aphis pomi*).

THE SWEET CLOVER APHIS

(*Aphis medicaginis* Koch.)

This small black plant louse, while having a decided preference for certain legumes, as the sweet clovers, the locos, black locust, and wild Licuorice (*Glycyrrhiza lepidota*), feeds to some extent upon a very wide range of plants. We have frequently found it upon tender new shoots of apple and other fruit trees early in the season, and have received inquiries concerning it.

The wingless lice, when fully grown, are very deep shining black. Other wingless individuals of the colony are dark green to slaty gray but not black. From these colors alone the orchardist will be able to distinguish this from other species attacking the apple. Whether the colonies of this louse upon the apple came from stem-mothers hatching from over winter eggs has not been determined. We have never seen the eggs or true sexual forms of this species anywhere. It is not likely that this louse will ever become a serious orchard pest.

PEACH PLANT LICE

THE GREEN PEACH APHIS

(*Myzus persicae* Sulz.)

Plate II, Figs. 5 to 11.

This is by far the most abundant peach louse in Colorado. It seems to have been brought to this country from Europe where it was first described by Sulzer as a peach insect in 1761. Forty years later Shrank, finding it upon *Dianthus* (the pink) gave it the specific name *dianthi*. Koch in Germany redescribed it under

zation of malifolii, as given by Fitch. So we are calling our rosy apple aphis **Aphis pyri** Boyer, until we get further light upon the subject.

It might be added that the **Aphis sorbi** described by Buckton, Vol. II, p. 83, and which is referred to by Schouteden as this species in his paper ("Catalogue des Aphides de Belgique," p. 228), in "Memoires de la Soc. Entom. de Belgique, T. XII," is not **sorbi** unless both the descriptions and the illustrations are very incorrect, and the specimens we have from Dr. Cholodkovsky incorrectly determined.

the same name in 1854, and especially tells of taking it from Calla lily and the Oleander. Walker, an English writer about 1840, speaking of this louse says that it feeds upon at least sixty known plants and names the potato, turnip, cabbage, lily, carnation, tulip, tobacco, peach, nectarine, and many others. Buckton, in his "Monograph of British Aphididae" in 1879, speaks of this

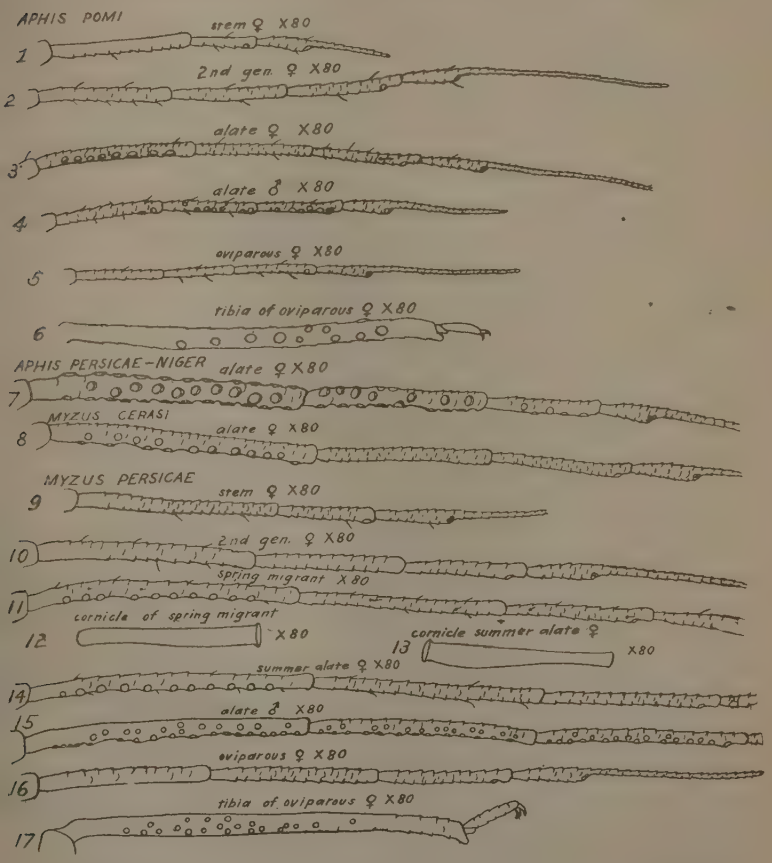
APHIS POMI
1 stem ♀ X80
2 2nd gen. ♀ X80
3 alate ♀ X80
4 alate ♂ X80
5 oviparous ♀ X80
6 tibia of oviparous ♀ X80
APHIS PERSICAE-NIGER
7 alate ♀ X80
MYZUS CERASI
8 alate ♀ X80
MYZUS PERSICAE
9 stem ♀ X80
10 2nd gen. ♀ X80
11 spring migrant X80
12 cornicle of spring migrant X80
13 cornicle summer alate ♀ X80
14 summer alate ♀ X80
15 alate ♂ X80
16 oviparous ♀ X80
17 tibia of oviparous ♀ X80
COLO AGR. EXP. STA.
18 stem ♀ X80
19 alate ♀ X80
MP

PLATE IV. Antennae, tibiae and cornicles of plant lice.
M. A. PALMER, ARTIST.

louse as being almost "polyphagus," on account of its feeding upon so many different plants.

In America this louse has also been reported under different names upon the peach, plum, cherry and man succulent plants. including several of our garden vegetables. The *Rhopalosiphum solani* of Thomas, occurring in abundance upon potatoes in Illinois; the *Siphonophora achryantes* of Monell, and the *Myzus malvae* of Oestlund* are almost certainly this *persicae* of Sulzer, which was described nearly a century and a half ago. Since arriving at the above conclusions* a letter has been received from Dr. N. Cholodkovsky of St. Petersburg, to whom specimens of this louse were sent and which were determined by him as being the *persicae* of Sulzer which he considers identical with the *dianthi of* Koch.

NAME AND LIFE HISTORY

There are two main reasons why this insect has been described under so many different names. It has a habit, which is not uncommon among the plant lice, of spending the fall, winter and spring of the year upon certain trees and shrubs, and the remainder of the year upon succulent vegetables. The winged form occurring upon the trees in the spring of the year (Plate II, Fig. 8) has its cornicles cylindrical in form while the winged individuals occurring upon succulent vegetation during the summer and fall, and those that return to the peach and other trees in September and October, (Plate II, Fig. 9) have their cornicles moderately swollen. The latter type of cornicle puts this louse into the genus *Rhopalosiphum*, while the former type of cornicle with the swollen antennal tubercles and first antennal joint, puts it into the genus *Myzus*. The other reason for the numerous names is its feeding upon a very wide range of plants.

So we are unable to avoid the rather sweeping conclusion that the green peach louse with its cylindrical cornicles, its pink egg-laying females in the fall and similarly colored stem-females in the early spring, is only the tree form of the green louse with club shaped cornicles that is so abundant in green-houses upon carnations, snapdragons, lilies, and many other flowering plants and out of doors cabbage, cauliflower, radish, turnip, potato, and a host of other vegetables, both wild and cultivated, which has been des-

* The **Rhopalosiphum sonchi** of Oestlund, which, in "Synopsis of the Aphididae of Minnesota," he seemed inclined to give up to **Rhopalosiphum dianthi** of Shrank, is probably a good species. At least, the native **Sonchus** growing in the vicinity of Fort Collins is badly infested with a **Rhopalosiphum that** is certainly distinct from the louse here discussed, and it fits in every particular the description given by Professor Oestlund for **R. sonchi.**

* See Journal of Economic Ent., Vol. I, No. 2, p. 84.

ignated by the various names given above along with others that we have not mentioned.

This insect, then spends the winter, either as wingless lice upon succulent vegetables where there is sufficient protection to enable them to endure the cold weather, or in the egg stage upon certain trees, chiefly the peach, plum, apricot, nectarine and cherry.

The eggs are shining black in color and are deposited in the axils of the buds for the most part, but some occur in crevices of the bark. The eggs hatch very early in the spring so that the young stem-mothers (Fig. 5) from them are often almost fully grown before the earliest peach or plum blossoms open. About the time the buds begin to open upon these trees, the stem-mothers are all of a deep pink color and begin giving birth to living young. These young (Fig. 6) instead of being pink like their mothers are pale yellowish green throughout their lives, and usually there is a median and two lateral dark green stripes passing over the abdomen. Very few of this brood attain wings. The third generation become very largely winged (Fig. 8) and begin leaving the trees upon which they were born about the middle of May in the peach growing sections of the state. By the middle of June these lice have almost completely left the trees and may be found establishing their colonies upon various succulent vegetables, a list of which is given below. At this date, (Aug. 1, '08) this louse in the insectary, bred directly from specimens taken from the peach in Fort Collins, June 20, are all apterous and the body color is a uniform pale yellow without green markings.

FOOD PLANTS

The plants upon which we have found this louse establishing colonies in Colorado are as follows:

IN GREENHOUSE

Snapdragon **(Antirrhinum sp.)**
Carnation **(Dianthus sp.)**
Potato **(Solanum tuberosum)**
Radish **(Raphanus sativus)**
Alternanthera.
Calla lily **(Richardia Africana).**
Lilium candidum.
Tulip **(Tulipa sp.)**
Cauliflower **(Brassica oleracea).**
Lactuca spicata.
Turnip **(Brassica rapa).**
Tobacco **(Nicotiana Tabacum).**
Egg-plant **(Solanum Melongena).**
Amaranthus sp.
Chenopodium album.
Water Cress **(Roxipa Nasturtium).**
Asparagus fern **(Asparagus sp.)**
Nasturtium **(Tropaeolum majus).**
Red Clover **(Trifolium pratense).**
White clover **(Trifolium repens).**
Verbena sp.
Russian thistle **(Salsola tragus).**
Cotton **(Gossypium herbaceum).**
Box-elder **(Rulac negundo).**
Snowball **(Viburnum opulus).**
Apple **(Pyrus malus).**
Wheat **(Triticum sativum).**
Grass **(Poa sp.)**
Corn **(Zea sp.)**
Willow **(Salix sp.)**
Castor bean **(Ricinus communis).**
Cineraria sp.
Pot Marigold **(Calendula officinalis).**
Fetid Marigold **(Drysodia sp.).**
Digitalis purpurea.
Primula Forbesi.
Stellaria media.
Iresine lindeni (Achyranthes).
Tomato (Lycopersicum esculentum).

Malva sp., native.
Tanacetum balsamifera.
Poppy, cultivated.
Vinca sp.
Vicia sp.
Lupine, native wild pea.
Sugar beet **(Beta vulgaris).**
Cantaloupe **(Melo sp.)**
Watermelon **(Citrullus vulgaris).**
Native thistle **(Carduus sp.)**
Chrysanthemum sp.
Marsilea vestita.
Golden glow **(Rudbeckia sp.)**
Cactus **(Opuntia sp.)**

OUT-OF-DOORS

Trees upon which eggs are laid.
Peach **(Prunus persica).**
Plum **(Prunus domestica** and **Americana).**
Choke cherry **(Prunus Virginiana).**
Prune **(Prunus domestica).**
Nectarine.
Tame cherry **(Prunus cerasus).**
Apricot **(Prunus Armeniaca).**
Sand cherry **(Prunus melanocarpa).**

SUMMER FOOD PLANTS ONLY

Cabbage **(Brassica oleracea).**
Cauliflower **(Brassica oleracea).**
Rape **(Brassica napus).**
Turnip **(Brassisca Rapa).**
Potato **(Solanum tuberosum).**
Tulips **(Tulipa sp.)**
Pansy **(Viola tricolor).**
Pigweed **(Chenopodium album).**
Radish **(Raphanus sativus).**
Amarantus sp.
Chenopodium **(Bonus-Henricus.)**
Malvastrum coccineum.
Wild mustard.
Lepidium sp.
Dock **(Rumex sp.)**
Bursa Bursa-pastoris.
Tomato **(Lycopersicum esculentum).**
Water cress **(Nasturtium officinale).**
Apple **(Pyrus malus).**
Pear **(Pyrus communis).**
Lilac **(Syringa vulgaris).**
Castor bean **(Ricinus communis).**
Morning glory **(Convolvulus sp.),** wild
Hollyhock **(Althaea rosea).**
Horseradish **(Nasturtium armoracea).**

Immune plants—The following plants in the insectary were not infested: onion, beegnia, oxalis, (four-leaved sorrel), and coleas.

Apparently, the only reason why the above list of infested greenhouse plants is not larger is because there was not a larger list of plants growing in the greenhouse at the time. It seems that this louse will feed upon almost any tender green foliage early in the spring, or late in the fall when most plants have died out and the lice are hard pressed for food.

A plant louse like this that is able to spend the winter either upon trees in the egg stage or as a louse upon succulent vegetables that are somewhat protected from the extremes of low temperature, and with such a wide range of food plants, has a remarkable power to continue its existence in a locality where it has once been introduced.

INJURIES

When the peach trees bloom, this louse often attacks the blossoms in numbers sufficient to blight them. After the fruit forms they sometimes attack the young peaches in sufficient numbers to cause them to wilt and drop. They also attack the leaves causing them to curl and turn yellow in color and, if the attack is very severe, many of the leaves drop.

NATURAL ENEMIES

This louse is attacked by a large number of insect enemies and it is probable that its severe struggle for existence with these

foes is what accounts for its wide range of food plants and its intricate life history.

The predaceous enemies such as lady-beetles, syrphus flies and lace-wing flies are very abundant about the colonies of this insect, and at least two small internal parasites* also destroy them.

REMEDIES

About a week before the buds open, spray the trees with the ordinary strength of kerosene emulsion (one-fifteenth oil) or with Black Leaf 1 to 65 in water, or with some other good plant louse spray recommended for the green apple aphis. After the trees have blossomed, if the lice become abundant at any time, spray as for the green apple aphis.

If the peach trees are to be treated with lime-sulfur for twig borer, or brown mites before the buds open, that application should kill nearly all of the stem mothers of this louse too, if made a week or ten days before the buds open.

THE BLACK PEACH APHIS

(*Aphis persicae-niger* Smith)

Plate I, Figs. 12, 13, 14.

This louse has long been known as a pest in peach orchards in the United States where is seems to be a native insect. This seems strange, however, as the peach is a native of Asia and appears to be the only food plant for this louse. We first noted the black peach aphis in Colorado in 1905. It has not become very generally distributed in the peach orchards of the State as yet, but is known to occur in a few localities upon the western slope and at Canon City. The infested orchards are so situated, however, that it will be an easy matter in a few years for the louse to distribute itself throughout nearly all the important peach sections.

It is important, therefore, for all who grow peaches to give the closest attention to their orchards for the purpose of detecting this louse as soon as it appears and destroying it, before it becomes so widely distributed that it cannot be kept under control.

APPEARANCE OF THE INSECT

This louse differs quite widely in its habits and appearance from other species that attack the peach, and is one that any fruit grower can readily determine if he will give close attention to the characterization here given.

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* A species of **Lysiphlebus** destroys large numbers, especially in greenhouses, and we have also a number of the lice killed by a very minute Chalcid (**Aphelinus** sp.), which causes the lice to turn deep shining black in color. Lice parasitized by **Lysiphlebus** become swollen and turn to a gray, or light drab color. Those killed by the Chalcid retain their natural shape. Determined for us by Dr. L. O. Howard.

While this insect is known as the Black Peach Aphis, the greater number of the individuals in any colony are always of a reddish-yellow or amber color (Plate I, Fig. 13). It is only the full grown lice that are black, whether winged or wingless, and none of the individuals are ever green in color. The fully grown wingless lice are deep shining black and highly polished (Plate I, Fig. 12.

The other lice occurring upon the peach attack the foliage and blossoms and in some cases the young peaches, but none of them attack the year-old bark of the limbs as does this one.

LIFE HISTORY

This louse appears very early in the season. Last year it was found in Delta County and also in the vicinity of Palisades, early in February in considerable numbers, and badly infested twigs were received from Paonia that were taken March 18, 1908. These early appearing lice confine their attacks to the tender bark of the twigs and are nearly always most abundant at first upon small limbs or sprouts near the ground. The tender twigs may be literally covered with the lice before the leaves open at all. When the buds do open, exposing the leaves and blossoms, some of the lice migrate upon these tender parts. They may kill the little peaches, and if at all abundant upon the leaves, the latter curl and protect the lice from storms or from the insecticides that may be thrown upon the tree by the orchardist.

The lice that appear upon the trees early in the season are all wingless. The winged examples begin to appear in the vicinity of Grand Junction about the last of April. By the tenth of May these winged lice are usually very abundant, and by the middle of May, in our experience, the lice have begun to disappear from the peach trees and very few have been found in the orchards after the 15th of June.

It is said that this louse migrates to the roots of the peach trees where it spends the fall and winter coming back to the top early in the spring. This part of the life history we have been unable to verify although we have dug about many peach trees in search of the lice.

That it is the habit of this insect to pass the winter upon the roots of trees seems highly probable as we have been unable to find any sexual forms or eggs, and we are not aware that any one has.

In the older peach growing sections of the country this aphis has been reported as frequently killing peach trees, especially small ones in nurseries.

PREVENTION AND REMEDIES

It is not very uncommon for horticultural inspectors to find

this louse present upon the roots of nursery stock that has been shipped into the state. Undoubtedly the lice present in Colorado today, have descended from those brought to the state in this manner, and not in the egg stage.

It is a matter of much importance then, to treat all nursery stock coming to Colorado in such a way as to prevent any possibility of introducing this louse into the peach orchards upon nursery trees.

This may be done either by a thorough fumigation of the stock with hydrocyanic acid gas; or by thoroughly and forcefully spraying it with kerosene emulsion, a good quality of whale oil soap, or a tobacco decoction, before planting.

If the louse has been introduced into the orchards and is found to be present upon peach trees it is highly important that the owner keep a very close watch over his trees especially in the early spring time for the purpose of detecting the first appearance of these lice, which would probably be during the latter part of February or sometime in March in the warmer sections of the state. In the colder sections where peaches are grown to some extent, the earliest date of their appearance would probably be the latter part of March or very early in April. As indicated above, the louse may become very abundant before the buds open at all, and that is when treatment of orchards trees can be made most effective and with least expense. So far as our observations have gone, the lime-sulfur preparations have not been satisfactory for the control of this louse, but it is very readily killed by the ordinary application of soaps, tobacco preparations or oil emulsions. We would especially recommend kerosene emulsion that is 1-15 oil; "Black Leaf," 1 gallon in 65 gallons water; or home made tobacco decoction. If the treatment is made one week before the buds begin to open, the green peach aphis will also be killed by the same application.

Thorough treatment should always be made before the winged forms begin to appear, which may be as early as the middle of April.

This louse is very gregarious in habit so that it will often be the case that one or two trees, or even one side, or a few limbs upon a tree, may be quite badly attacked when no other infested trees are found in the orchard.

PLUM LICE

Besides being attacked somewhat by the green peach louse (*M. persicae*) plum and prune trees have three other species of plant lice of considerable importance in Colorado.

THE MEALY PLUM LOUSE

Hyalopterus arundinis (Fab.)

This is a light green louse that colonizes the underside of the

leaves of plum and prune trees. It often is so numerous that th under leaf surface is completely covered by the lice.

The stem-mothers hatch from black shining eggs deposite upon the twigs of the trees late in the fall. They locate upon th underside of young growing leaves where they give birth to large number of living young which, so far as we have observed do not acquire wings. At Austin, Colorado, May 22, '08, many o the second generation were mature and producing young. In th earlier sections this louse becomes very abundant by the 10th t the 15th of May and may continue to about the 15th or 20th o July when nearly all will have acquired wings and left the trees About Fort Collins, at least, we find that occasional colonies o this louse remain upon plum trees throughout the summer.

Upon leaving the plum, the lice go to certain grasses to feed during the summer. We have specially found it infesting Reed-grass, *Phragmites Phragmites,* on wet ground and along ditches upon the western slope in Colorado.

About the middle of September* the fall migrants begin to return to the plum trees and to give birth to the sexual males and females. The males are winged and the females wingless. The latter deposit the eggs that remain over winter.

This louse may be easily distinguished from other plum infesting species by its light green color, with three longitudinal darker stripes above, the white powdery covering to the body, the long narrow body, the short cornicles, and the small second fork in the third sector of the fore wing. The leaves when loaded with this louse, may drop and become yellow but they do not curl as is so often the case in plant louse attacks.

REMEDIES

The lice will leave of their own accord by about July 10 in the warmer portions of the state and a little later in other sections. If found very abundant before July 1st, it will doubtless pay to make a thorough spraying with kerosene emulsion or Black Leaf as recommended for the green apple aphis.

This louse seems to have few natural enemies to keep it in check.

THE HOP PLANT LOUSE

(*Phorodon humuli* Schrank)

This is another green louse that inhabits the plum as a winter host plant. This louse is specially noted for its severe injuries to the hop during the summer months. It is generally distributed in the state and has frequently been taken by us upon both cultivated

* September 16, 1906, is our earliest date for return migrants to the plum.

and wild hops and upon plums.

At Fort Collins we have followed it upon the plum in moderate numbers throughout the entire season, and Mr. W. T. Clark* has reported it remaining upon the hop vines in California until the males and egg-laying females have been produced. So it seems probable that this louse can exist from year to year upon either of these food plants in the absence of the other.

For an excellent account of the life habits of this insect and colored figures of the different stages, see an article by C. V. Riley in Department of Agriculture Report for 1888, p. 93.

While we have not observed the stem-mothers in Colorado, we find the louse appearing during May and the early part of June upon the leaves of plum trees. Most of the lice acquire wings and leave early in July in the vicinity of Fort Collins, though on July 8, 1907, trees were seen badly infested with this louse and there were many wingless adult females still present.

APPEARANCE OF THE LICE

The wingless lice are light green or greenish yellow without noticeable markings of other colors. The winged lice have the same general body color with head, plates of the meso-thorax above, and a few dashes upon the abdomen black. All the lice are specially marked by having upon the head, at the base of each antenna, a prominent tubercle or tooth, and a less prominent one projects from the inner side of the first joint of the antenna.

About the middle of September at Fort Collins the winged return migrants begin to come from the hops and alight upon the leaves of the plum. A note made at that place October 3, '07, reads: "The winged migrants are fairly common on plum leaves now and most of them have a small colony of young surrounding them." These young develop into the wingless egg-laying females (and possibly winged males also) and a little later the eggs are deposited upon the twigs to live over winter.

REMEDIES

The same as for the green apple aphis.

THE RUSTY BROWN PLUM LOUSE

(*Aphis setariae.* Thos.)

This plum louse is readily distinguished from any of the other species mentioned in this bulletin by its dark rusty brown color together with the conspicuous white base of the antennae, entire tibiae, and tail or cauda.

This louse appears early in the season upon the bark and leaves of the tender new shoots of plum trees. We have found it

* Bull. 106, Calif. Experiment Station, 1904.

specially upon the red or Americana plums. Throughout the season it seems to have a strong tendency to cluster upon the bark of the tenderest new growth.

The louse is nearly always accompanied by ants, that attend it for the honey dew that is secreted. Usually in the colonies a few larvae of one of the small black Coccinellids (*Scymnus* sp.) can be seen. They are recognized at once by the white secretion that covers their bodies.

This louse remains upon the plum throughout the entire year. We have found it in many places east of the mountains both in the vicinity of Fort Collins and in the Arkansas Valley, but we have not taken it on the western slope. It often becomes abundant enough to be a very serious pest, but on account of its body being entirely free from any powdery secretions, it is readily treated and destroyed. From about the first of August on through the summer we have also found this louse upon barnyard grass (*Echinochloa Crus-galli.*) The louse becomes darker in color late in the season and the oviparious female in the fall is almost black. The small winged males are black in color. The egg-laying females are wingless and, in the laboratory, Mr. Bragg succeeded in getting them to lay eggs quite freely upon plum twigs, but he was unable to find any of the eggs upon infested plum trees out of doors. The lice upon plum trees during September and October were all apterous except the males, but whenever found upon barnyard grass there were many winged individuals present that seemed to be fall migrants.

Mr. J. T. Monell* reported this louse upon *Panicum proliferum*) in Missouri, and Professor O. W. Oestlund** reports it upon fox-tail (*Setaria glauca*), barnyard grass (*Echinochloa Crus-galli*) and Virginia Creeper (*Ampelopsis quinquefolia* in Minnesota.

REMEDIES

The remedies for this louse are the same as for the green apple aphis, without the early treatments for the destruction of eggs.

THE BLACK CHERRY LOUSE

(*Myzus cerasi* Fab.)

Plate II, Figs. 1, 2, 3, 4.

This is an insect that has long been known in Europe and for more than half a century, at least, has been a pest upon cultivated cherries in the eastern portion of this country. It is generally distributed through the orchards of the eastern slope of the Rocky Mountains in Colorado and has found its way into a few orchards,

* Bull. 5, U. S. Geol. Survey, p. 23, 1878.
** Aphids of Minn., p. 67, 1887.

in the valley of the Gunnison. Prompt action on the part of the orchardists where it occurs would almost exterminate it from our Western Slope.

Both the winged and wingless forms of this louse are deep shining black, the body is rather broad and flat and the cornicles are long and clyindrical. Cherry foliage may be fairly blackened by the lice before the early cherries mature.

Dr. C. M. Weed,* who studied this louse in Ohio, found winged lice appearing in great numbers about June 10 to July 1st, and all lice disappeared by the latter part of July and remained off the cherry until late in September when he began to find winged migrants again. Though no alternate food plants were found, Dr. Weed was convinced that such plants existed and that it is the instinct of the louse to entirely leave the cherry trees during the late part of the summer. We have followed this louse quite closely for two years past about Fort Collins and have found its habits about as follows:,

The lice first attract attention about the last of May upon sprouts about the trees, then upon the lower limbs, and by the middle of June may be all through the trees. About the first week in July their enemies, especially the lady-beetles, become very abundant and the lice rapidly disappear so that by the middle or latter part of the month they can only be found in scattered isolated colonies. Some of these escape their enemies and the lice gradually increase in numbers again late in August and in September, but, so far as we have observed, do not again become very numerous. At least, this louse did continue in this manner throughout the entire summer in 1907 and 1908 about Fort Collins where it was closely watched for us by both Mr. L. C. Bragg and Mr. T. D. Urbahns.

Up to about June 15th. at Fort Collins, practically no winged lice can be found and by July 1st. the great majority of the lice are either winged or pupae, and a good proportion of winged individuals continue in the colonies throughout the season.

Besides the observations of the writers, Mr. L. C. Bragg has spent a considerable portion of his time every week of the year for more than two years past inspecting plants of every kind growing in the vicinity of Fort Collins, yet this louse has never been seen by any of us upon any plant but the cultivated cherry. We are obliged to conclude, therefore, that this louse has no other regular food plant in Colorado.

REMEDIES

This louse should be treated with kerosene emulsion or one of the tobacco preparations before the winged lice appear to spread

* Bull. Ohio Experiment Station, Technical Series, Vol. I, No. 2, p. 111, 1890.

the species from tree to tree. The earlier this is done after the lice first appear the better, for then they are nearly all accumulated upon a few sprouts or limbs near the ground.

PREPARATION OF THE INSECTICIDES MENTIONED IN THIS BULLETIN.

KEROSENE EMULSIONS

The standard formula for mixing the stock solution of kerosene emulsion is as follows:

Water 1 gallon.

Tak-a-Nap, Whale-oil, or Laundry soap 1-2 pound.

Kerosene, 2 gallons.

For use, dilute with water to secure the desired percentage of oil.

For example, if a spray containing 5 per cent oil is desired, use 3 3-4 gallons of the stock solution, and dilute with water to make 50 gallons of spray. If a 6 per cent spray is desired, use4 1-2 gallons of the stock solution to make 50 gallons of spray, or if a 7 per cent spray is desired, use 5 1-4 gallons of the stock solution in making up 50 gallons, or practically 1 part stock solution to 9 parts of water. This last named strength is the one most commonly used for the destruction of plant lice upon plants while they are in foliage. Larger amounts of the stock solution may be prepared using the same ratio. If a stronger spray is to be used than those given above, it is only necessary to dilute with a smaller proportion of water, bearing in mind in computing the percentage of oil in the spray that the stock solution is two-thirds oil.

The necessary steps are: Dissolve 1-2 pound soap in 1 gallon boiling water. While boiling hot add this to 2 gallons kerosene and briskly agitate for about five minutes. A creamy mixture will be formed which, when diluted with water, will mix readily without allowing free kerosene to rise to the top. After agitating, add a small quantity of the stock solution to a bucket of clear water for trial. It should mix completely through the water, like milk. If it rises to the top as free oil, the stock solution will have to be heated again to boiling and churned until it will stand this test. To avoid accidents, the boiling solutions should be removed from the fire when it is mixed with the kerosene. An emulsion can be formed with greater ease if the oil is also warmed, but the heating of kerosene over a live fire, for safety, should only be attempted out of doors and away from all buildings. The mixture must be watched closely also to prevent its boiling over the sides of the vessel and igniting.

Mixing the emulsion is not a difficult operation. It can be done by any orchardist. The essentials of success are in having the soap suds *boiling hot* when the solutin is added to the kerosene, in

giving *immediate and thorough agitation* when the boiling soap-suds and kerosene are poured together, and in the use of clean soft water.

The apparatus may vary with the amount to be prepared. Those preparing to use several spray tanks of the material and possessing a gasoline power spray outfit find it most convenient to perform the agitation by placing the boiling hot soap-suds and the kerosene together in the spray tank and forcing the mixture through the pump. This churns the liquid thoroughly. Mr. B. A. Smith of Grand Junction, successfully prepares enough of the stock emulsion at one time in this way for five two-hundred gallon tanks of 6 per cent spray. He first dissolves in a home-made cooking vat with galvanized iron bottom and wooden sides, thirty pounds soap with thirty gallons of water, and when this is boiling hot it is poured into the spray tank upon 60 gallons of kerosene previously emptied into the tank. The gasoline engine then forces the mixture through the pump and a short spray hose back into the tank under a high pressure for several minutes until oil and soap-suds are completely combined. The whole solution, about 100 gallons, is then run off into an extra dismounted spray tank and 1-5 of the stock solution used for each 200 gallon tank, thus giving approximately 6 per cent oil in the spray. The apparatus is equipped with a mechanical agitator in the tank which operates while the emulsion is being made, but the action of these mechanical agitators will not alone form a good emulsion, and the mixture must also be pumped as described out from the tank through a spraying nozzle hose and back into the tank again.

Enough for a two hundred gallon spray tank may be made in a 50 gallon barrel fitted with a good hand barrel pump for agitation. Smaller amounts may be prepared with wash-boilers or tubs as heating vessels for the soap-suds, and to contain the oil and soap-suds when being emulsified and a good hand bucket pump will perform the agitation. If a very small quantity is to be used for a few house plants an egg beater will suffice for the agitation.

Many kinds of soap may be used to prepare the emulsion. Tak-a-Nap soap, whale-oil soap and Laundry soap have been most commonly used by the growers. The cost of the soaps should be considered. Tak-a-Nap soap is a soft soap and disolves readily. It should be heated to boiling in water when dissolved the same as other soaps insure the best results, instead of attempting to combine soap-suds and kerosene cold.

Those who have trouble in making kerosene emulsion can procure a commercial article known as "Aphisicide" manufactured at Grand Junction, or else use some other good contact insecticide instead.

PRECAUTIONS

When preparing and using kerosene emulsion remember:

To use soft clean water is possible.

To have the mixture as hot as possible for emulsifying.

To see that the oil, or mixture of oil and soapy water does not boil over into the fire.

To see that the oil does not separate to form a layer of kerosene on top. If this condition exists, the last of the barrel or tank will be almost sure to burn the foliage.

To remember that the strength of the emulsion depends upon the percentage of oil it contains.

To use kerosene emulsion alone, do not try to combine it with arsenical sprays.

To apply forcefully and thoroughly so as to wet the insects as it only kills by coming in actual contact with their bodies.

TOBACCO DECOCTION

Tobacco stems or tobacco dust two pounds.

Water four gallons.

Put the tobacco in the water which may be either cold or hot. Place over the fire and when the water has reached the boiling point, remove some of the fire and allow the water to simmer, but not boil,* for fully one hour, when the liquid is ready to be drained off and applied.

If the whole leaf tobacco is used, prepare as above using one pound of tobacco to each four gallons of water.

No lime or other akaline substances should be added to the tobacco while cooking. Apply at once, or within a few days after making.

BLACK LEAF

There is nothing to do in the preparation of Black Leaf except to thoroughly stir the contents of the can before pouring out any quantity for dilution. In most cases one gallon of the Black Leaf will be found sufficient for each seventy gallons of water. If in the treatment of any louse this does not seem sufficient it may be used in the proportion of one gallon to sixty or sixty-five gallons of water. In fact, we have usually succeeded in killing plant lice with this preparation used in the proportion of one gallon to each one hundred gallons of water. Thoroughness of application is of as much importance as the strength of the material used.

If this substance is not obtainable in your home town it may be procured from the Watkins Merchandise Co., Denver, or from The Kentucky Tobacco Product Co., Louisville, Kentucky.

*Dr. W. P. Headden, Station chemist, says that nicotine will be partially driven off by boiling. A distillate he prepared killed lice when diluted to 1-8 strength.

MISCIBLE OILS

There are several miscible oils upon the market which may be added directly to water forming a milky emulsion at once. In the preparation of any of these, such as "Scalecide," "Target Brand Scale Destroyer" or "Killoscale" add the oil directly to the water with a little stirring. One gallon of the miscible oil in fifty gallons of water will make a two per cent. mixture, which in most cases, should be strong enough to kill plant lice if thoroughly applied.

(FOR WINTER SPRAY ONL.

LIME-SULPHUR MIXTURE

FLOWERS OF SULFUR, FIFTEEN POUNDS

Good lump lime, fifteen pounds. Water, forty-five gallons.

This is the 1-1-3 lime-sulfur mixture. First slake the lump lime with sufficient warm water, and while still boiling hot, add the sulfur and stir it in. Place over the fire and continue the boiling, adding water when necessary, until the mixture changes to a deep reddish brown color which indicates that the lime has cut the sulfur. It will be necessary to boil steadily for about forty minutes to one hour to produce this result. The mixture should then be diluted to form forty-five gallons of the spray, and should be applied at once.

When the lime-sulfur mixture is placed in the barrel or tank it should be strained through gunny sacking to take out all lumps that would clog the spray nozzle. If allowed to stand for any great length of time after being prepared, the lime sulfur crystalizes out to a considerable extent. In such a case it is necessary to heat the mixture again before applying so as to dissolve all the crystals. If the crystals are re-dissolved the mixture will be as strong as before.

To make 1-1-2 lime-sulfur mixture, prepare as above using only thirty gallons of water for the fifteen pounds of lime and the fifteen pounds of sulfur.

For the 1-1-4 lime-sulfur mixture prepare in the same manner, but dilute to sixty gallons before applying.

REX LIME-SULFUR

We have found the Rex lime-sulfur in the proportion one gallon of the Rex to seven or eight gallons of water to be just about equal in effect to the 1-1-3 home made lime sulfur preparation.

WHALE-OIL OR FISH-OIL SOAPS

The so-called Whale-oil or fish-oil soaps which are quite extensively used for the destruction of plant lice will usually be effective if thoroughly applied in the proportion of one pound of the soap to each six or eight gallons of water. There are numerous brands of these soaps upon the market. Those that we have used successfully are Good's Whale Oil Soap and Bowker's Tree Soap.

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Bulletin 134. Sept. 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Orchard Plant Lice

AND

Their Remedies

BY

C. P. GILLETTE

E. P. TAYLOR

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

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ORCHARD PLANT LICE AND THEIR REMEDIES.*

C. P. GILLETTE AND E. P. TAYLOR.

The plant lice that are commonly designated as "aphids" have very similar habits, structures, and remedies. These should be known and understood by the farmer and fruit grower who have to contend with them. Nearly all of these lice are rather easily destroyed when proper remedies are intelligently applied to them. Probably the plant lice here mentioned are the most serious orchard pests in Colorado at the present time.

GENERAL STRUCTURE AND HABITS.

All of the plant lice get their food by inserting a beak and sucking the sap of the plant. They never eat away the tissue of the leaf.

Throughout the entire summer, from spring to about the first of September, all of our plant lice that infest orchard trees, increase in numbers by giving birth to living young. If eggs are laid at all they are deposited by the last brood of females in the fall. From the fact that a single louse is usually able to give birth to from 75 to 150 young, and as they mature in about eight to ten days after being born, it will readily be seen that the plant lice are capable of increasing with wonderful rapidity. This accounts for the fact that the lice may nearly all be killed from a tree and that tree be very seriously infested with the lice again within a few weeks. Usually the last brood in the fall are about one half males and one half females. These females deposit the eggs that live over winter and the lice all die. We have an exception of this rule, however, in case of the woolly apple aphis which lives over winter as young or partly grown lice upon the trunk and branches, and in all stages of growth upon the roots of the trees.

Plant louse eggs usually hatch in the spring a little before the leaf buds begin to open on the trees that they infest. These early lice hatching from the eggs are always wingless in the species mentioned in this bulletin, and are called stem-mothers. These stem-mothers mature in a short time, are all females, and begin giving birth to young lice which constitute the second brood. It is seldom that the second brood of lice have more than a very few winged ones. The remainder of the life history of these lice will be given under the different species treated.

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*This bulletin is an abbreviated edition of Bulletin 133, "A Few Orchard Plant Lice," by C. P. Gillette and E. P. Taylor, and is prepared to give the most important information needed by fruit growers. Bulletin 133 gives a much fuller account of the plant lice, and is illustrated by colored plates of some of the most important species. The technical matter, and that which does not relate to the economical side is omitted from this edition, which is intended to meet the needs of most people.

Bulletin 133 will be sent on request made to the Director.

ANTS AND HONEY DEW

Wherever the aphids are abundant, it is usually true that ants may be seen running over the infested tree or plant. It is often thought by the orchardist or farmer that the ants are present to destroy the lice, but this is probably never the case. Nearly all plant lice excrete from their bodies a sweet liquid known as "honey dew." This liquid, gathering upon the leaves of the plants, cause them to be shiny and sticky as if they had been varnished. The ants are very fond of this liquid and visit the lice to obtain it, and are always very careful not to injure the plant lice themselves.

NATURAL REMEDIES

The plant lice are greatly lessened in numbers every year by insect enemies. Most important among these are the "lady-beetles," the "syrphus flies," and the "lace-wing flies" or "aphis-lions." Wherever these are found upon the infested plants they should be carefully protected as they often destroy the lice so completely that it is not necessary to make any application to kill the lice artificially.

REMEDIES

The most common remedies for the destruction of plant lice are kerosene emulsion, tobacco decoctions, or soapy preparations. An insecticide that will destroy one plant louse will usually be effectual in destroying any other, if a thorough application is made.

Plant lice fly so freely from one orchard to another that it is very important that all of the orchardists in a community spray their trees whenever the lice are abundant. If one man should fail to do this, the plant lice leaving his trees, would in nearly every case, be sufficient to thoroughly colonize all of the orchards near him. Co-operation then is very important in any campaign against plant lice.

APPLE PLANT LICE.

WOOLLY APPLE APHIS. (*Schizoneura lanigera Hausm.*)

This is probably the most serious apple pest in Colorado. It is a bark feeder, and it attacks both the roots, the trunk and the limbs of the trees, but does not feed upon the fruit or foliage. This louse is readily recognized on account of its being covered with a white woolly secretion which has suggested its common name. Upon the trunk and branches the lice attack either the tender bark about the scars or the bark of tender new shoots. Below ground, the lice attack the bark of the smaller roots causing warty swellings upon them. If very abundant, the roots are often completely covered with these smooth wart-like growths which sometimes cause the roots to die and rot off. When very abundant upon the very rapidly growing twigs, these lice often produce abrupt swellings due to the thickening of the inner bark. Sometimes these swollen portions of the limbs crack open lengthwise and the limbs may be sufficiently injured to case them to die. Severest injury is done to the tops where there is the tenderest and most rapid growth as in grafts and water sprouts.

LIFE HABITS

The life habits of this insect may be briefly stated as follows: Early in the spring there will be a few living lice in protected places beneath the bark or under the dead bodies of the lice that were killed the previous fall, There will also be a large number of lice living over upon the roots of the tree beneath the surface of the ground. The lice that live over on top are all very small. Those living over upon the roots are of all sizes from the smallest to those that are fully grown. By the time that the buds begin to open in the spring, the lice that live over on top will locate on tender new bark and insert their beaks and begin to suck the sap of the tree and to grow in size. At the same time a greater or less number of small lice that live over winter about the crown of the trees, and perhaps some that came up from the roots, migrate to the top and begin to feed and grow. These lice start the round of development for the year on the tree tops. They are usually first detected by the fruit grower when the little lice have grown enough to secrete a white covering to their bodies which makes them appear like little mouldy spots upon the bark. These lice increase very rapidly in number so that by the middle of June or first of July the tree may be very badly infested and the cottony secretion may be so heavy as to hang down and even fall from the bodies of the lice.

The lice are all wingless until about the first of September when an occasional wigned louse may usually be found upon the trees. These lice leave the trees where they develop and fiy to others. Each of these winged lice gives birth to about four or five males and as many females. Before winter comes on, each female deposits a single egg and dies. No one seems to have followed this part of the life history of the woolly aphis in the orchard. It is supposed that these eggs hatch the following spring and start new colonies.

Upon the roots of the trees the woolly aphis lives in large numbers the year around, the only difference in the winter being that the lice reproduce very slowly, so do not increase much in numbers. The cold weather seems never to be sufficient to kill them even in our coldest climates where the apple is grown.

PREVENTION

Prevention is nearly always better than the cure. Great care should be taken therefore, when setting out a new orchard, to prevent the introduction of this louse. Orchards are usually infested by the lice that are upon the roots of the nursery trees when they are set out. All nursery stock should be thoroughly disinfected either by fumigation with hydrocyanic acid gas, or by very thorough spraying of the trees, both roots and branches, before they are set, with one of the remedies mentioned below for spraying tops.

One method of preventing injuries from this louse is to have all apple trees upon Northern Spy roots, as Northern Spy seems never to be seriously attacked by this insect.

If nursery stock is received with roots "puddled," covered with mud, the purchaser should insist upon this mud being thoroughly washed off, and the roots treated for woolly aphis, as this is one of the methods that the nursey man has of covering up woolly aphis upon his nursery stock.

To prevent the spread of the woolly aphis from tree to tree and orchard to orchard, the lice should be well cleaned out of the orchard before the first week of September as it is about this time when the winged lice begin to fly about to spread the species.

REMEDIES ABOVE GROUND

Wherever this louse can be reached by sprays it may be destroyed like other plant lice, but one precaution is necessary, the spray must be applied with sufficient force to remove or penetrate the wooly covering. There are several spray materials that we have found entirely successful when thoroughly applied to this insect.

Kerosene Emulsion—According to our experience, a good kerosene emulsion has no superior for the destruction of this insect. It seems to penetrate the woolly covering rather better than most other insecticides. When used in the ordinary strength (1/15 oil) we have always found it efficient. In the proportion of one-twentieth oil (5%), we have usually found it sufficiently strong if applied with a good deal of force and thoroughness.

Directions for preparing kerosene emulsion are given on a later page.

To be most successful, apply as a moderately coarse spray and with a pressure, if possible, of one hundred forty to one hundred eighty pounds.

Scalecide and Other Miscible Oils—There are upon the market a number of so-called miscible oils which, when put into water, break up at once into very fine particles forming a milky white emulsion. These oils we have found fairly successful. Two to three gallons are used in each one hundred gallons of water. After being prepared, if these oils separate out so as to form an oily film upon the surface of the water, they should not be used.

Soaps—We have found the standard whale-oil soaps such as "Good's Whale Oil Soap" and "Bowker's Tree Soap" quite effectual for the destruction of this louse when used in the proportion of one pound of soap to each six or eight gallons of water.

Black Leaf—The Kentucky Tobacco Product Co., of Louisville, Kentucky, manufacture a tobacco extract which they sell under the above trade name and which has become very popular among the orchardists of Delta County, Colorado, as a spray for orchard plant lice. We have tested it quite thoroughly and have found it very efficient for the woolly aphis if used in the proportion of one gallon of the Black Leaf in sixty-five to seventy gallons of water. In fact, we have usually been successful when using Black Leaf as weak as one gallon to one hundred gallons of water. This strength, however, requires very thorough application. It would be a good plan for any one to treat a few trees with varying strengths of this or any other insecticide for the destruction of lice a day or two before taking up his general spraying work, for the purpose of determining whether or not the strength that he contemplates using is sufficient to kill the lice. In this way he may save many dollars, from using the insecticides in a strength that will not do the work or in a proportion unnecessarily strong.

Tobacco Decoction—If any prefer to make their own tobacco decoctions, they may use tobacco stems or tobacco dust or whole-leaf to-

bacco. Fruit men, however, have not reported very uniform results from their own preparations. This may be due to adulterations in the tobacco or from different methods of preparing the decoction. For the preparation of tobacco decoctions see under Preparation of Insecticides, below.

It might be advisable for one who has very much spraying to do to grow his own tobacco. Mr. W. S. Coburn, President of the Colorado State Board of Horticulture, tells us that he has had excellent success using tobacco of his own raising. He uses the whole leaf and makes a decoction using one pound of tobacco for each six gallons of water. The tobacco is steeped for at least one hour, and then applied warm.

Lime-Sulfur Sprays—The lime-sulfur sprays have not been successful in destroying the woolly aphis during the summer season when the body is covered with the woolly secretion. It has been fairly successful when applied two or three weeks before the buds open for the destruction of the little lice that live over winter upon the trees and which do not have their bodies protected by the secretion.

LATE WINTER OR EARLY SPRING APPLICATIONS

So far, the remedies mentioned have been for summer treatments, when the bodies of the lice are more or less covered with the waxy secretion. We believe the best time to get results in the treatment of this louse is late in the winter or early in spring before the buds open. This is not because the lice get protection from the opening buds, but because by the time the buds have opened, the lice have their bodies more or less covered by the waxy secretions that protect them to some extent from the effects of the insecticides.

Orchards in the Grand Valley treated early in the spring of 1907 for the destruction of the eggs of the green apple aphis were also largely freed from the woolly aphis. The insecticides that were found successful in the destruction of these little over-winter lice were:

Lime 15 pounds, sulfur 15 pounds, water 30 gallons.
Lime 15 pounds, sulfur 15 pounds, water 45 gallons.
Rex lime-sulfur 1 gal., water 7 gal., lump lime 2 lbs.

Lime 15 pounds, sulfur 15 pounds and water 60 gallons was a little weak and did not give results that were fully satisfactory, and the same was true of Rex 1 gallon, water 7 gallons, without the addition of lime.

We have no doubt but what the kerosene emulsion, the soluble oil sprays, the tobacco sprays and the whale-oil soaps mentioned above could also be used successfully as early spring sprays for the destruction of the over-winter lice upon the tree tops, though we have not tested them in that way. As they are not as successful for the destruction of the eggs of the green apple aphis, and as the orchardist is likely to want to destroy both of these lice at the same time if possible, it is probable that the lime-sulfur sprays will become most popular for early spring applications.

To get best results on the woolly aphis the spring application should be made fully a week or ten days before the apple buds begin to open at all, and the trunk and crown of the tree should be thoroughly drenched. Then as a final act for best results, put Tanglefoot bands about the trunks of the

trees so that the lice at the roots can not migrate to the top. For the application of these bands see next paragraph.

TANGLEFOOT BANDS

In the experiments upon the Western Slope in particular, large numbers of Tanglefoot bands have been used. This material is put out by the O. & W. Thum Co., Grand Rapids, Michigan and is the sticky material put upon the Tanglefoot Fly-Paper. When at all abundant upon the trees, the newly born lice are much inclined to travel about and it is often astonish to see the number of lice that will be captured in these bands. On the 7th of June, 1907, it was estimated that bands that had been on since the preceding fall had as many as 100,000 lice each in many cases. The bands remain fresh for several months and may be quickly freshened by rubbing a paddle over them, when they become filled with insects and dirt.

Apparently these bands do no harm to trees, but what their effect might be when continued for years we are unable to say.* In most instances we have put them directly upon the bark but it would be safer, so far as any possible injury to the tree is concerned, to put a band of stout paper around the trunk and then put the Tanglefoot upon that. To make certain that no lice should pass under the band, a light band of the cheapest cotton batting under the paper would be advisable. This band, in connection with the spring spraying mentioned above, we believe to be the surest method of freeing the tree tops of woolly aphis.

MOUNDING AND CULTIVATING

The woolly aphis is not a burrowing insect in any true sense of the word. The lice that come down the trees get into the ground by way of the cracks or other openings in the soil that are large enough to allow them to enter. The lice that sometimes infest distant roots do not get to them by crawling there all the way from the crown of the tree but they get down to them directly from the surface above. So far as possible, the descending over-winter lice congregate about the crown of the tree where they are able to get below the surface in the large cracks between the trunk and the earth. The migration both to and from the roots can be somewhat, often very largely, prevented by cultivating the surface of the soil and by stirring and compacting and even slightly mounding the earth about the crown of the tree and by re-stirring this earth when it becomes compact after a rain or an irrigation.

TRIMMINGS

When the lice become very abundant upon water sprouts and suckers, something can be done to lessen the number by thoroughly cutting out these growths. A thorough thinning of the top so that plenty of sunlight can enter has been noticed to lessen the number of lice which find the most congenial locations for their development in dense shade and upon the north side of the limbs, at least in sunny Colorado.

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*Mr. Geo. P. Weldon, reports, from recent observations upon the Western Slope in Colorado, rather severe injuries from the application of Tanglefoot bands that have been directly upon the bark for a year or more.

TREATMENT BELOW GROUND

The treatment below ground is all aimed at the lice that are within three feet of the crown of the tree and within one foot of the surface. It should also be remembered that the same substances that will kill the lice above ground will also kill them below ground if they can only be put in contact with the lice, and then the orchardist should be cautious not to accumulate in the soil about the crowns of his trees substances that are likely either presently or after years of repetition, to do his trees an injury.

EXPERIMENTS IN GRAND VALLEY

A rather extensive series of experiments for the purpose of testing substances that seemed to offer some promise of good results were carried through in irrigated orchards of the Grand Valley in Colorado, a summary of which is given below.

THE APPLICATIONS AND THEIR RESULTS

The experiments were begun in the fall of 1906 and the winter following The materials used upon the roots were Kerosene Emulsion, Scalecide, Chloroleum, Black Leaf Dip, tobacco dust, tobacco dust decoction, tobacco stems, tobacco stem decoction, quick lime, lime-sulfur mixture, Rex lime-sulfur, whale-oil soap, and carbon bisulfid.

Before making the applications the earth was removed over the main roots to a depth of about 6 inches, and for a distance of about 2 feet upon all sides, of each tree. One man on an average would expose the roots of about 100 trees a day. Into these dirt basins which varied some in depth and diameter with the size and depth of the roots of the trees, the liquids were forcefully sprayed so as to well drench the exposed portions. And when the liquid had nearly or quite soaked into the ground the basin was filled again and the earth banked well about the trees. In hard compact soils it is best to irrigate a few days prior to making the treatment so as to loosen the soil, and lessen the labor of excavating about the trees.

Summing up the results to September, 1907, it may be said, that practically all strengths of kerosene emulsion (3% to 50%), killed the lice well when the roots had been well treated. Where less than 6% of oil was used, the odor of kerosene soon disappeared and reinfestation soon took place by the lice that migrated downward from the top. Where, 7, 10, and 15% of oil was used the effect was still more lasting; and the 20, 33 and 50% treatments gave practically perfect freedom from lice about the crown and roots throughout the season.

A later examination was made by Mr. George P. Weldon, 1908. Mr. Weldon found the woolly aphis about equally abundant upon the treated and untreated trees in all of the blocks. Even those that were treated with 50% kerosene emulsion were badly infested upon the roots at the time that he made his examination. So we have to conclude that any treatment for the destruction of the woolly aphis upon the roots is only of temporary value. But the stronger preparations do repel the lice for a short period of time, perhaps two or three months. Mr. Weldon also found that where the 50% emulsion was used the trees appeared to be seriously affected and

probably would not live through another year. None of the weaker preparations seem to have done any injury to the trees.

CONCLUSIONS AS TO BEST METHODS OF TREATMENT

Just before the buds open in the spring, spray very thoroughly with a 7% kerosene emulsion, a 1 to 60 Black Leaf Dip (or some other strong tobacco decoction), or a good whale-oil soap, 1-lb to 6 gallons of water. Spray the entire trunk and also the ground about the crown of the tree at the same time. Immediately after treatment apply a Tanglefoot band over cotton so as to prevent the upward migration. If the lice become very numerous at any time upon the tops, spray them forcefully with the 7% emulsion, or Black Leaf, 1 part in 70 parts of water.

Root treatments are temporary in their effects. When the roots become very badly infested, treat as above described with 10% kerosene emulsion, Black Leaf Dip (1 to 50), 2 to 3 gallons to a tree, or if the soil is quite open and porous, carbon bisulfid.*

CARBON BISULFID

This insecticide has often been reported successful against this insect. A splendid opportunity was afforded to observe its results in the 20 acre orchard of Mr. F. D. Barney, where about 200 pounds of the liquid was used on 12-year-old apple trees. The treatment was begun on April 11, 1907, and was continued several weeks from this date.

A shovel was thrust deeply into the ground about 18 inches to two feet from the base of the tree with the blade broadcast to the tree. The handle was then tipped forward and the carbon bisulfid poured into the bottom and at the center of the opening at the back of the shovel. The shovel was then withdrawn and the earth packed upon the spot treated. The liquid was not poured directly upon the roots. From three to six holes were treated in this way about each tree and about three ounces of the liquid used. At this rate the cost of the material did not amount to as much as three cents per tree.

TOBACCO DUST AND STEMS

Dry tobacco in the form of tobacco dust or tobacco stems or even the whole leaf tobacco when used freely about the trees has not given very satisfactory results. Apparently these substances are of no use unless the tobacco is thoroughly wet, as soon as it has been placed about the roots, so that the juices will penetrate the soil and kill the lice. In a few instances orchardists have reported very satisfactory results but in nearly all cases they have reported failure. We believe if tobacco is used at all against this insect upon the roots of trees the best method is to apply it in the form of a strong decoction.

Prepare as for a top spray and use two or three gallons about each tree as in case of kerosene emulsion as described above. The tobacco does not have as lasting an effect apparently as does the emulsion.

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*Carbon bisulfid may be procured in quantity from Edward R. Taylor, Penn Yan, New York.

Tobacco decoction in which two pounds of stems, or dust, or one pound of whole leaf tobacco was used to each three gallons of water and forcefully sprayed upon the exposed roots gave fairly good results but these were not equal in their killing and repelling effects to a 10 to 15% kerosene emulsion.

Black Leaf Dip used in the proportion of 1 gallon in 65 gallons of water gave results similar to the preceding.

Scalecide used 1 to 40, 1 to 50 and 1 to 60 in water killed the lice fairly well but had very little repelling effect afterwards.

Lump Lime applied in a manner similar to that employed with the tobacco stems, 10 to 20 pounds to a tree, was of little or no benefit.

Soaps used for root treatment were of doubtful benefit.

Some Wholly Unsuccessful Substances were, "Chloroleum" potash lye, wood ashes, salt, and flooding with water for several hours.

THE GREEN APPLE APHIS. (*Aphis pomi DeGeer.*)

This is the common green louse curling the leaves of the apple tree in Colorado. While primarially a leaf feeder this louse also attacks the tender tips of growing shoots, especially grafts and water sprouts. This insect ranks close to the woolly aphis in extent of injuries to the apple trees. It also attacks the pear, the thorn and the quince quite freely.

LIFE HISTORY

This louse remains upon the apple, or closely allied trees, throughout the year and does not go upon other trees or vegetables.

The first lice in the spring hatch from eggs that were deposited the previous fall upon the twigs of the trees. These first lice hatch a few days before the buds open and are ready to insert their sharp beaks into the first tender green tissue of the opening buds. These lice are all females and become fully grown in about two or three weeks, when they begin giving birth to living young. From this time on the lice increase very rapidly if they are not kept down by their natural enemies or the insecticides of the orchardist.

At first all the lice are wingless, but by the 10th to the 15th of May in the warmer portions of the state, and about two weeks later in the cooler orchard sections, the winged lice begin to appear and to fly from tree to tree and orchard to orchard with the prevailing winds. About the first week in September little brown wingless males and green wingless egg-laying females will appear, and a little later the females will begin laying green eggs that soon turn black upon the apple twigs. The freezing nights in November or early December kill all the lice and the eggs live over to hatch the following spring.

REMEDIES

Treatment for this insect may be for the destruction of the eggs and young lice before the buds open in the spring, or for the destruction of the lice upon the leaves during the growing season.

TO DESTROY THE EGGS

Kerosene Emulsion in all our experiments has proven useless

for the destruction of the eggs except when applied so strong as to make it entirely impractical to use it.

The Lime-Sulfur Mixtures—Either the 1-1-2, or the 1-1-3 formula or Rex lime-sulfur in dilutions down to 1 gallon in 8 gallons of water, have given good results. Lime-sulfur by the 1-1-4 formula is a little weak for good results.

Black Leaf—This preparation used in the proportion of 1 gallon in 25, and 1 gallon in 33 of water gave good results, but 1 gallon in 40 gallons of water was not very satisfactory, many of the eggs hatching.

SUMMER SPRAYING

For the destruction of the lice upon the leaves spray very thoroughly and forcefully from all directions with kerosene emulsion, 5 to 7 per cent. oil; Black Leaf, 1 part in 70 parts of water; or one of the other plant louse sprays discussed at the close of this bulletin, remembering that **thorough and forceful applications** are necessary in order to get best results.

PEACH PLANT LICE.

There are two species of plant lice attacking peach trees in Colorado, the Green Peach Aphis (*Myzus persicae Sulz.*) and the Black Peach Aphis (*Aphis persicae-niger Smith.*) The former is very generally distributed and occurs nearly every where that this fruit is grown, while the latter occurs in isolated orchards only, and might be kept down so as to do no appreciable harm, and it is quite possible that it might be practical to exterminate it from the state.

THE GREEN PEACH APHIS

Is distinguished by its pale green, or greenish yellow color in the wingless forms and the winged lice have the same general ground color to their bodies with more or less of black markings above.

The lice appear very early in the spring and often attack the blossoms, and the young peaches when the latter first form, causing them to wilt and drop. Later it attacks the leaves causing them to curl and turn yellow. By the middle of the summer this louse leaves the peach trees and goes to cabbages, turnips, radishes, tomatoes, potatoes and many other growing crops, as well as many of the common weeds. The lice remain upon these plants during the summer and in the fall there are winged forms that return to the peach to give birth to true males and females, the latter of which deposit the eggs that remain upon the twigs of the trees during winter to hatch out the early lice of the following spring.

REMEDIES

Spray thoroughly with kerosene emulsion, Black Leaf (1 part in 60 of water), or a solution of whale-oil soap (1 pound to 6 gallons of water), about three or four days before the blossoms open. Then, if the lice appear later, treat as in case of the green apple aphis.

THE BLACK PEACH APHIS

This louse is readily distinguished from any other attacking the peach

by its black color when fully grown, whether winged or wingless. The immature lice are of a yellow or amber color. In all stages, and especially in the spring, this louse will be found upon the bark of the small limbs where it continues to feed after the leaves appear. Many of the lice will go upon the leaves also causing them to curl.

Like the preceding species, this louse also disappears by the middle of July or the first of August without anything being done for it, but it does not go to any other plants so far as known, but is said to descend to the roots of the peach where it remains until the following spring. So far as known this species does not lay eggs but lives over winter as a louse.

This insect is continually being shipped into Colorado upon the roots of nursery stock. Our Horticultural law and the vigilence of our county horticultural inspectors has done much to keep it out of the orchards, but it is impossible, under present methods, to prevent an occasional tree, infested with this louse, being planted.

REMEDIES

All peach trees, before being planted, should be thoroughly fumigated, or dipped or sprayed with Black Leaf, a home-made tobacco decoction, or a good kerosene emulsion.

The remedies in the orchard are the same as for the Green Peach Aphis mentioned above.

PLUM PLANT LICE.

THE MEALY PLUM LOUSE. (*Hyalopterus arundinis Fab.*)

A light green louse with a rather long narrow body that is covered with a fine white powder. The lice occur upon the under side of the leaves, which they may completely cover by the middle of June, but the leaves do not curl. By the first week in July, many of the lice are winged, and by the last of that month the lice will nearly all have left the plum. The lice go to certain grasses, especially the large coarse Reed-grass growing in wet places. In the fall winged migrants return to the plum where, later, the eggs are deposited by egg-laying females and the lice all die. The next spring the eggs hatch to continue the species.

REMEDIES

Spray as for the green peach aphis but use a heavy pressure and direct all of the spray upon the under side of the leaves where all the lice are. These lice are killed with difficulty on account of the powdery covering upon their bodies.

THE RUSTY PLUM LOUSE. (*Aphis setariae Thos.*)

This louse is readily distinguished from all others upon the plum by its dark brown body color, and with a hand lens one can usually see the conspicuous white legs, antennae and tail. This louse seems to have a preference for the tender bark near the tips of rapidly growing shoots although it covers the undersides of the leaves also. At a little distance the louse may almost appear black to the naked eye. This louse spends the entire

year upon the plum, though it is known to attack barn grass **Echinochloa Crus-galli.**

The remedies for this louse are exactly the same as for the green peach aphis already mentioned.

THE BLACK CHERRY LOUSE. (*Myzus cerasi Fab.*)

This louse has long been known in Europe as a pest upon cherry trees. It is generally distributed throughout the cherry growing districts of the eastern slope in Colorado, but as yet only occurs in isolated orchards upon the western slope.

Those having cherry trees should make a vigorous attempt to exterminate this louse as soon as it is noticed in the cherry orchards. It could not be mistaken for any other insect upon the cherry tree as it is deep black in color and infests the under side of the leaves and the bark of the tender new growth. It is usually accompanied by ants in abundance. This insect remains upon the cherry, and so far as known, does not migrate to any other plant. On account of its numerous insect enemies it is likely to almost disappear for a time during the middle of the summer, but may continue quite abundant thoroughout the season. The last brood in the fall lay eggs which carry the species over winter to hatch in the spring.

The remedies are exactly the same as for the foregoing species.

THE HOP PLANT LOUSE. (*Phorodon humuli.*)

This is the green louse that has caused such severe losses in hop vineyards. The hop is the summer food-plant and in the fall winged hop lice migrate to the plum trees where the egg-laying females later deposite eggs upon the branches which hatch the following spring. These lice are very similar to the preceding in general appearance but lack the heavy covering of powder. While most of the lice leave the trees for the hop before the middle of July, we have found some of the lice remaining throughout the summer on plum leaves.

REMEDIES

The same as for the green peach aphis.

PREPARATION OF A FEW IMPORTANT PLANT LOUSE INSECTICIDES

Kerosene Emulsion—Prepare in the following proportions:

Soap one half pound.
Water one gallon.
Kerosene two gallons.

To prepare, dissolve one half pound of soap in one gallon of soft water by boiling; when well dissolved and still boiling hot, remove from the fire and add two gallons of kerosene, and agitate at once as briskly as possible. If large quantities are being made, a good way to emulsify is to use a force pump and spraying nozzel and pump the mixture as forcefully as possible back into the vessel containing it. If the emulsion is properly formed, the whole mass will appear much like whipped cream and will mix readilly in water without a film of oil rising to the top. Sometimes, when

the oil is rather cold, it lowers the temperature so much that a good emulsion is not obtained. In this case the dish may be placed back over the fire and the mixture heated to the boiling point when it must be again removed and agitated to form the emulsion. In case the mixture of soapy water and kerosene is placed over the fire, it must be watched every moment to see that it does not quickly boil over and take fire. As soon as emulsified, add twenty-seven gallons of water and use at once. This will make thirty gallons of the mixture, and such an emulsion will be one-fifteenth oil (or a 7% emulsion). This is the strength ordinarily used for the destruction of insects upon plants. For larger or smaller quantities, prepare in the same proportions.

Sometimes the emulsion is not perfect and a little oil rises to the top. In such cases, if the last in the barrel or tank is pumped out upon the foliage, it is likely to burn it. So it is advisable, unless the emulsion is of good quality, to throw out the last few gallons making no use of it.

It is best to dilute and apply kerosene emulsion as soon as it is prepared.

Avoid using alkali or any hard water in making the emulsion, as it will cause the oil to separate and rise to the top. Any clean soft water will usually give good results.

If a stronger emulsion is to be used, prepare as above, but do not use as much water in making the dilution. For example, if 17 gallons of water were added in place of 27 to dilute the emulsion, it would be one-tenth oil or a ten per cent. emulsion, and if 37 gallons were added, it would be a five per cent. emulsion.

Those who have trouble in making kerosene emulsion can procure a commercial article known as "Aphiscide" manufactured at Grand Junction, or else use one of the tobacco preparations instead.

Tobacco Decoction—

Tobacco stems or tobacco dust two pounds.

Water four gallons.

Put the tobacco in the water, enought to cover, which may be either cold or hot. Place over the fire and when the water has reached the boiling point, remove some of the fire and allow the water to simply simmer for fully one hour, when the liquid is ready to be drained off, diluted to the above proportions and applied.*

If whole-leaf tobacco is used, prepare as above using one pound of tobacco to each four gallons of water.

No lime or other alkaline substances should be added to the tobacco while cooking. Apply at once, or within a few days after making if possible.

Black Leaf—There is nothing to do in the preparation of Black Leaf except to thoroughly stir the contents of the can before pouring out any quantity for dilution. In most cases one gallon of the Black Leaf will be found sufficient for each seventy gallons of water. But if in the treatment of any louse this does not seem sufficient it may be used in proportion

*Dr. W. P. Headden, Chemist of the Experiment Station, has proven that the nicotine is rapidly driven off by boiling, and especially where the water is strongly alkaline.

of one gallon to sixty or sixty-five gallons of water. We have usually succeeded in killing plant lice with this preparation in the proportion of one gallon to each one hundred gallons of water. Thoroughness of application is of as much importance as the strength of the material used.

If this substance is not obtainable in your home town it may be procured from the Watkins Merchandise Co., Denver, or The Kentucky Tobacco Product Co., Louisville, Kentucky.

Miscible Oils—There are several miscible oils upon the market which may be added directly to water forming a milky emulsion at once. In the preparation of any of these, such as "Scalecide," or "Target Brand Scale Destroyer" or "Killoscale," add the oil directly to the water with a little stirring. One gallon of the miscible oil in 30 to 50 gallons of water will make a mixture, which in most cases will be strong enough to kill plant lice, if thoroughly applied.

Lime-Sulfur Mixture—(For winter spray only.)

Flowers of sulfur, fifteen pounds.
Good lump lime, fifteen pounds.
Water, forty-five gallons.

This is the 1-1-3 lime-sulfur mixture. First slake the lump lime with sufficient warm water, and while still boiling hot add the sulfur and stir it in. Place over fire and continue the boiling, adding water when necessary, until the mixture changes to a deep reddish brown color which indicates that the lime has cut the sulfur. It will be necessary to boil steadily for about forty minutes to one hour to produce this result. The mixture should then be diluted to form forty-five gallons of the spray, and should be applied at once.

When the lime-sulfur mixture is placed in the barrel or tank it should be strained to take out all lumps that would clog the spray nozzle. If allowed to stand for any great length of time after being prepared, the lime-sulfur crystalizes out to a considerable extent. In such a case it is necessary to heat the mixture again before applying so as to dissolve all the crystals. If the crystals are re-dissolved the mixture will be as strong as before.

To make 1-1-2 lime sulfur mixture, prepare as above using only thirty gallons of water for the fifteen pounds of lime and the fifteen pounds of sulfur.

For the 1-1-4 lime-sulfur mixture prepare in the same manner, but dilute to sixty gallons before applying.

Rex Lime-Sulfur—We have found the Rex lime-sulfur in the proportion of one gallon of the Rex to seven or eight gallons of water to be just about equal in effect to the 1-1-3 home made lime-sulfur preparation. Rex lime-sulfur solution can be made white by the addition of lime at the rate of 5 to 10 pounds for each 50 gallons of spray.

Whale-Oil or Fish-Oil Soaps—The so-called whale-oil or fish-oil soaps which are quite extensively used for the destruction of plant lice, will usually be effective if thoroughly applied in the proportion of one pound of the soap to each six to eight gallons of water. There are numerous brands of these soaps upon the market. Those that we have used quite successfully are Good's Whale-Oil Soap and Bowker's Tree Soap.

Bulletin 135 December 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

THE AUSTRALIAN SALTBUSH

Its Composition and Digestibility

NOTES ON RUSSIAN THISTLE

BY

WM. P. HEADDEN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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AUSTRALIAN SALTBUSH (*Atriplex semibaccata*)

ITS COMPOSITION AND DIGESTIBILITY

NOTES ON RUSSIAN THISTLE

By WM. P. HEADDEN

The California Experiment Station received the seed of this saltbush from Baron Von Mueller in 1888. In 1899, Charles H. Shinn, in Bulletin 125, states as the result of eighteen years' experimentation with saltbushes at that station, "that the *Atriplex semibaccata*, is the most generally useful species of all that have been planted, although others are worthy of cultivation."

Very favorable reports concerning the value of this plant gained currency, and it seemed that it might be of value to Colorado, as it would furnish a desirable fodder for the stock in the eastern part of the State, where the rainfall is sometimes insufficient for the production of good corps of other forage plants. This view was entertained by the writer previous to the appearance of the bulletin above referred to and seemed to be confirmed by the facts set forth therein. A small quantity of seed was procured in the spring of 1900 and planted on land previously used for experiments with sugar beets. The seeds were drilled in very shallow, but still too deep according to subsequent experience and a very poor stand was obtained—except in spots, where the plants were too thick.

The growth of the plants was entirely satisfactory, some of them attaining a diameter of seven feet and they bore an abundance of seed. I left the plot till the next spring, hoping to learn whether the seed would germinate and furnish me plants enough for the work of the ensuing year. In the meantime, however, a change had been made in the chair of agriculture and the new incumbent, knowing nothing about my work, plowed up my plot. This will explain why some of the statements in this account of the plant in Colorado are based on a garden experiment.

So far as the general culture of the plant is concerned the only question that presents any trouble is in getting it established; when once established it will seed itself abundantly. The best way to obtain a stand of this plant, in the beginning at least, is by transplanting; one can, of course, drill the seed. If this is done, the drills should be at least eight feet apart. The young plants, if well hardened and stocky, will need a little water when first set out to start them well, but when once established they will stand neglect, drought, and more abuse than most plants.

The seed, if they are plump, and fairly fresh, will germinate freely, but will rot if covered deeply. If they are sown in boxes, it is best to firm them and scarcely cover them at all. Good results

may be obtained by simply firming the seed on the soil and covering for a day or two with a thin cloth of any sort which can be kept moist. A similar observation concerning the depth of sowing is made by the California Station in Bulletin 125.

The first season's experience with this plant was on a poorly drained, alkali soil, and while for reasons already given, the experiment was not as satisfactory as one might wish, the results sufficed to show that the plant will do well under such conditions and furnish a large amount of fodder. Some of the single plants attained a diameter of seven feet. The garden experiment was in the main more successful, though less attention was paid to it. The plants seeded heavily and were not gathered, but left where they grew. They proved to be easily killed by freezing—it is stated in the California bulletin that the plants will endure a temperature of 14° F. below the freezing point.

My plants in the garden plot all perished during the winter, but the seed came up very freely the following spring, and this little plantation maintained itself for the next five seasons with but little care and without other water than our usual rainfall.

The California station made observations on the amount of rainfall necessary for this plant to make some growth, not a luxuriant growth whereby single plants attain a diameter of twelve or more feet, but sufficient when planted in rows two feet apart to cover the ground. They state that "one-fifth of an acre, sown in December, yielded 100 pounds of seed. This plot was cut in September and, cured for fodder, yielded at the rate of five and one-half tons of hay per acre. Three such cuttings were practicable on this light, granitic, sandy loam, underlaid by hard pan, during the driest season known." The rainfall for this season, 1897-'98, is given as 4.75 inches. The plant makes a remarkable growth with a very small supply of water. The writer of the bulletin referred to states further that, "on unirrigated land there was no green fodder-plant excepting saltbush (*A. semibaccata*), in the entire region." The rainfall during the seasons that the plant grew in my garden without irrigation was not noted, and while it was certainly larger than this recorded at one of the California sub-stations, it was not sufficient for the growth of our ordinary grasses.

This plant grows on the ground, not erect like alfalfa, but spreads out into a circular mass varying in diameter. Well-grown individual plants in our plot attained a diameter of seven feet, but single plants are recorded as having attained, in California, a diameter of even eighteen feet. The stems are slender and leafy.

The habit of the plant makes it hard to cut, and the leaves are easily lost in making hay—this plant is, of course, not to be considered as a forage plant where alfalfa can be grown—but its drought

resisting power may make it worthy of consideration by some people in this State. In our eastern counties, I have seen Russian thistle hay and have been informed that it was highly prized. I took this statement *cum grano salis* because the hay did not look to me as though it were fit to be eaten by any kind of stock and I saw no proof that the stock liked it. Mr. Payne, of Akron, suggests that Russian thistle hay may have a place in the feed of the plains stock as a laxative, for constipation is not uncommon among them. The Russian thistle is used to a limited extent in other parts of the State for hay making, and inquiry elicited from a thrifty, energetic ranchman the information that he had found it entirely unsatisfactory. Further, I have known the saltbush, *A. argentea*, to have been made into hay not for constant use, but as an emergency fodder for periods when the stock could not obtain enough to eat, or indeed anything by grazing. In sections where forage plants are such a desideratum as in these just referred to, any plant having better qualities than the indigenous ones or such as have been imported would be a blessing. This is really the reason for presenting this bulletin, for in this Australian saltbush, *A. semibaccata*, we have a plant which will reproduce itself freely from seed; the little plants will bear transplanting quite well; it will resist drought after it is well rooted and produce an amount of hay greater than the thistle now occasionally used, and of certainly as good or a better quality. In the sections of the country to which reference has been made small crops of sorghum can be grown, not always enough to be called a crop, but sometimes a fair one. This sorghum is not, especially in the spring of the year, a good fodder. It has no spines, as the thistle hay has, but sheep fed on it—sorghum fodder—lost weight rapidly. I know nothing about either the yield or quality of milo maize, but as compared with the other fodders mentioned, the Australian saltbush hay, though not presenting an attractive appearance, is worthy of consideration and that not as a portion of a ration but as a fodder to be given alone, for the question presenting itself to those persons in Colorado who may find it to their advantage to grow this as a forage plant, will in all probability be, not what they may mix to produce an advantageous ration, but simply as to what they can obtain to feed. The fact that they have used the so-called sand grass of the plains, Russian thistle, sunflower, and the native saltbush, *Atriplex argentea*, for the purpose of hay making indicates clearly that anything as good or better than the best of these, which they can grow, is at least a desirable thing for them.

The study of this plant had another object in view, or perhaps it is more nearly correct to state that in the beginning the object was to study its merits as a fodder and its adaptability to Colorado conditions, but in the end the object was extended to what we may

more properly designate as a chemical study of the fodder. It was advisable then from either standpoint to study the effects of the hay when fed alone, and it is not intended that any statement made shall be construed as indicating that hay made from this plant might not give more satisfactory results than will be presented in this bulletin if properly mixed with some other fodder but, as already stated, the conditions under which it would have to be fed have alone been considered.

So far as the readiness with which this saltbush can be grown is concerned and its ability to make a good growth with a small supply of water it commends itself. The other questions pertaining to it may be succinctly stated in a few words, does it present difficulties in cutting and being made into hay, will animals eat it readily and do they do well on it, *i. e.*, does it furnish sufficient nourishment to maintain or perhaps fatten the animals?

Under our conditions the plant is an annual which forms a spreading mass of growth on the ground, unless planted very thick, as it is apt to be in the case of self-seeding, when it might be feasible to mow it and handle it as we handle alfalfa in hay making. If, however, the plants are single it would seem necessary to adopt some other system of gathering it, probably the best method would be to turn up one side of the row and cut off the root with a chisel-like instrument. It would have to be handled as green as possible as, when dry, the leaves drop off badly.

The statement is made that animals eat it readily. To again quote the California Bulletin 125, p. 8: "At Tulare sub-station saltbush was fed to sheep, cattle, horses and hogs. With sheep the ration was increased until some received nearly their whole sustenance for months at a time from this plant, keeping in excellent condition, and being turned off to the butcher as 'fat mutton' without any other food except a little straw."

Other testimony on this point given on the same page, but by correspondents, is by no means so favorable, for some say "stock won't eat it." All shades of opinion between these two extremes seem to have been expressed by the correspondents in regard to the readiness with which it is eaten. On page 26 of the same bulletin, Prof. Jaffa states: "It is not advisable to feed the saltbush alone, particularly in the air-dried state, owing to the high percentage of the saline ingredients, and the general uninviting appearance and condition of the saltbush hay. In cases of emergency, however, sheep and cattle have existed altogether on this material through an entire season." These quoted statements, at least some of them, are general statements which contemplate other saltbushes as well as the *A. semibaccata*, which is the one had in mind in this bulletin.

We have fed it both green and dried, but almost exclusively to sheep. In one experiment we fed it to a horse. When fed green we had no trouble in inducing a lot of three sheep to eat it. The horse had been pasturing on it to some extent before we began feeding it to him as his only fodder. The sheep were fully matured animals in good condition; the weather during the time of the experiment, as well as all other conditions under which it was made, were altogether favorable. The time of feeding between weighings was three weeks. The result was that the lot had neither gained nor lost. The horse was not weighed, but we assumed that he had not lost materially, if at all; he ate the green fodder readily. At first the sheep showed the laxative qualities of the saltbush to a slight etxent, but this was of short duration and was at no time serious; the horse also showed it at first, but in this case it was also of short duration. There is doubtlessly a difference in individual animals in regard to the effects of this as well as any other fodder and it may be of a little interest to some to know that of the three sheep fed in this experiment, one gained a pound, one lost a pound, and the third just maintained its weight.

The green fodder was not analyzed, nor was there any account taken of the amount of the green fodder eaten; the only care taken was that they should have as much of the fresh fodder as they would eat. Samples of hay, however, were prepared from plants taken from different portions of the plot, as it varied considerably in the character of its soil. This feature of the experiment will not be mentioned further, but it is probably the cause of the very considerable variations shown in the analyses of these samples.

The plot of ground on which the saltbush grew was in parts as strongly alkalized as any of which I had knowledge and was poorly drained, still we had previously grown sugar beets on the plot and obtained a yield of 19 tons to the acre and the beets were of excellent quality. Some portions of the plot, too, had been manured, so that it is quite right that the samples of saltbush hay should vary somewhat in their composition if these things have any influence on the composition of growing plants.

As to the amount of hay we would be justified in expecting to obtain from an acre, I can give no opinion, as no data on this point was obtained.

I have grown some of this plant for the past eight seasons, but at no time since the first season have I had it on a measured plot, and the first season I obtained nothing like a good stand. On this point I will again quote Bulletin 125 of the California Station: "In February, 1896, saltbush seed was drilled here on the surface, in rows eight feet apart, and by September, when visited, the surface

was nearly covered. A part of the crop was cut twice, yielding at the rate of four tons of hay per acre." This is a very modest yield compared with those indicated by some of the correspondents, which would figure out at least one-half more. This may all be interpreted when applied to our conditions that the saltbush may be expected to yield a large crop of hay per acre provided the stand is good.

The composition of the crop of 1900 is given in the following table:

COMPOSITION OF SALTBUSH (*A. semibaccata*) HAY.

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Sample 1	6.16	17.90	1.18	13.21	23.79	37.76
Sample 2	7.94	19.48	1.09	13.70	24.34	33.45
Sample 3	8.34	17.02	1.17	9.41	28.31	35.75
Sample 4	8.45	15.07	1.12	8.70	28.00	38.66

For the leaves and stems we obtained the following:

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Leaves	6.42	24.29	1.66	15.92	8.99	42.72
Stems	5.25	8.75	0.72	6.46	44.67	34.15

The ratio of leaves to stems in a sample grown in 1906, which we may assume to be representative, was 8.6 to 6.5, or in round numbers, 60 per cent. leaves and 40 per cent. stems, according to which an average hay should contain about 12.2 per cent. proteids based on the analyses of leaves and stems given above, but the average percentage of protein indicated by the analyses of the four samples of hay is 11.26 per cent. This average is probably too low, owing to the low percentage of this constituent in samples three and four, both of which contain about or even less than one-half the amount of proteids found in later samples.

The four analyses, as previously indicated, serve to show how this hay may vary in quality even from the same field when no other condition than the variation in soil conditions can be appealed to as suggesting a plausible explanation; this is apparently a sufficient cause for the lack of uniformity in the published analyses of this hay, which is evident from the following, which are all of such analyses that I have been able to find:

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Arizona Rep. 1903	6.30	17.90	2.11	14.13	20.75	38.81
California Bulletin 125	7.05	19.37	2.01	11.64	15.88	44.05
California Bulletin 125	10.00	17.74	1.47	14.14	20.18	36.54
South Dakota Bul. 69	7.40	13.09	2.05	18.87	25.97	32.62

In our analyses of the samples grown in 1900, we notice a variation of five per cent. in the protein content, but an extreme of

seven per cent. in the four analyses above quoted. In other samples which will be described later we will find that this hay may contain even a higher percentage of protein than is shown by the South Dakota sample.

A little over two years ago I thought the time opportune to publish these observations on the probable value of this saltbush, especially to those sections of the State where the rainfall is usually too scant to grow good crops of other forage, but on looking up the literature there seemed to be so little positively established, particularly concerning its digestibility and feeding value, that it seemed wise to defer publishing them until additional data relative to these points had become available. We, therefore, began anew and grew another crop of the saltbush and determined its coefficients of digestion, using three sheep, wethers going on two years old, for this purpose.

This crop was started by raising the seedlings in boxes and transplanting them, but owing to a number of things, over which I had no control, it was very late in June before the seedlings were transplanted to the plot set aside for this experiment. The soil was of good quality and in good condition and free from alkali, and the water used for irrigation was likewise free from these salts. The plants grew very well and seeded abundantly, though set out so late in the season. We had no intention of trying to establish the minimum length of the season sufficient to grow a fair crop of this hay, but the accidents happening to this experiment show that if the plants get a good start by July 1st they will do well in this portion of the State. This crop was gathered and cured on sheets under the direction of Mr. F. Knorr, assistant in Agronomy, so that we had the whole plant, leaves and stems, to feed.

The sheep were taken from fattening pens, where they had been receiving a full feed of alfalfa hay and some grain. They at first received alfalfa hay alone, then alfalfa and saltbush hay, the latter being gradually increased till they received saltbush alone, when the preliminary period of the feeding began. The sheep had in the meantime become somewhat accustomed to being handled and also to their harness. The sheep did not seem to really like this hay, one in particular, sheep No. 1, continued to protest against it, but in the end the experiment proceeded quite satisfactorily. In the preceding experiment it will be recalled that we had sheep at last three years old. They were accustomed to the person feeding them, to the pens in which they were fed, and wore no harness to annoy them and were not handled. The result of feeding them green saltbush, a period of three weeks elapsing between weighings, was that the lot just maintained its weight with a variation of only one pound in any sheep. The fodder was green and more inviting

than the hay, and all of the conditions under which the experiment was conducted were favorable. In this second experiment we also used three sheep, young ones, and made them just as comfortable as possible, and again the results indicate that this hay fed alone will simply maintain the weight of the lot. In this case sheep No. 1 gained ¼ of a pound; sheep No. 2 gained ¾ of a pound, and sheep No. 3 lost ¼ of a pound. The total weight at the beginning of the feeding period was 243.25 pounds, at the end of the period 244.0 pounds, a gain of three-quarters of a pound. It was rather surprising that sheep No. 1 should show any gain, for the animal evidently did not like the hay and ate much less of it than the others, about two-fifths only of the average of the other two sheep. I will not go into the details of this case, but do not think that it should be included in averaging the results. The only good purpose that it serves is to show how very different the results with some individual animals may be from the average, and further to emphasize the fact that some individual animals do not take kindly to this fodder. Though the general tenor of the statements regarding this point would lead me to infer that sheep take to it better than other animals. The composition of this hay, made from quickly grown plants, the feeding data, composition of the feces and the coefficients of digestion are given below:

COMPOSITION OF THE SALTBUSH HAY, ORTS, AND FECES.

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	3.645	18.635	1.370	20.600	16.382	39.368
Orts—						
Sheep No. 1	3.610	21.668	1.460	20.820	15.233	37.209
Sheep No. 2	3.595	24.251	1.400	20.310	13.287	37.157
Sheep No. 3	3.485	22.156	1.400	20.500	14.502	37.957
Feces—						
Sheep No. 1	4.560	14.974	2.350	7.940	35.417	34.759
Sheep No. 2	4.525	15.894	2.240	8.090	32.142	37.109
Sheep No. 3	4.820	17.848	2.880	7.750	31.205	35.497

Experimental Data—Sheep No. 1 received 6,577 grams of hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	6337.27	1225.62	90.11	1354.86	1077.44	2589.24
Orts	4192.00	942.34	63.50	905.46	662.48	1618.22
Consumed	2145.27	283.28	26.61	449.40	414.96	871.02
Voided	1089.93	171.03	26.83	90.67	404.46	396.94
Digested	1055.34	112.25	-0.22	358.73	10.50	574.08
Coefficients of Digestion	**49.19**	**39.57**	.....	**79.74**	**2.53**	**58.85**

This animal weighed at the beginning of the experiment 78¼

pounds, and at the end 78½ pounds.

Sheep No. 2 received 7,938 grams of hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	7648.66	1479.30	108.76	1635.20	1300.40	3125.00
Orts	2056.32	517.28	29.86	433.21	283.41	792.56
Consumed	5592.34	962.02	78.90	1201.99	1016.99	2332.44
Voided	2195.93	365.57	51.52	186.07	739.26	853.51
Digested	3396.41	596.45	27.38	1015.92	277.73	1478.93
Coefficients of Digestion	60.87	62.00	34.70	84.52	27.31	63.41

This sheep weighed at the beginning of the experiment 79¼ pounds, and at the end 80 pounds.

Sheep No. 3 received 7,938 grams of hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	7648.66	1479.30	108.76	1635.20	1300.40	3125.00
Orts	2565.37	588.91	37.21	544.89	385.45	1008.89
Consumed	5083.29	890.39	71.55	1090.31	914.95	2116.11
Voided	2028.29	380.34	61.37	165.94	664.98	755.66
Digested	3055.00	501.05	10.18	924.37	249.97	1360.45
Coefficients of Digestion	60.10	57.28	14.23	84.78	27.29	64.29

This animal weighed at the beginning of the experiment 85.75, at the end 85.5 pounds.

The average coefficients of digestion for sheep Nos. 2 and 3 are, for the dry matter, 60.48; ash, 59.64; fat, 24.46; protein, 84.65; crude fibre, 27.30, and for the nitrogen free extract, 63.83.

The deportment of sheep No. 1 and the data showing the results obtained with this animal do not justify the inclusion of these results in stating the average coefficients found. We notice that the animal consumed only 2,145.27 grams of dry matter and digested 1,055.34 grams in five days and still maintained its weight or a little better, as it gained one-quarter of a pound. This animal was a light eater, even of alfalfa. In addition to these facts the coefficients of digestion are altogether too low in comparison with those found for the other sheep and can simply serve to show that the protein and nitrogen free extract have high coefficients of digestion, while the crude fibre is very difficultly digestible.

A comparison of these coefficients with some of our well known fodders may be of some service. The coefficients for alfalfa, timothy and native hay have been taken from Bulletin 93 of this Station. Those given for the oat hay are averages taken from Bulletin 77, p. 20, U. S. Department of Agriculture.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Alfalfa	62.05	57.67	29.86	72.54	49.93	72.89
Timothy hay	51.03	65.63	69.32	43.35	36.08	54.99
Native hay	50.53	42.52	20.55	62.33	55.56	51.30
Oat hay, average....	49.30	34.60	54.20	43.50	52.00	61.90
Saltbush hay (A. semibaccata)..	60.48	59.64	24.46	84.65	27.30	63.83

It will be observed that the composition of the saltbush compares very favorably with that of our best fodders. The proteids are high, especially in the South Dakota sample and the one used in our digestion experiments, 18.87 per cent. in the former and 20.60 per cent. in the latter. While the nitrogen free extract is lower than in the hay made from grasses it is quite as high as in the leguminous hays, alfalfa, or pea-vine hay. The crude fibre is low and the ash exceptionally high. The proteids present are not only high in percentage, but they also have a very high coefficient of digestion—84.65—which is, I believe, a higher coefficient than has been found for the proteids in any other hay and which has been approached in the case of but few hays. The ash is present in large quantities and is highly digestible, as one would expect, because it consists very largely of alkali salts. No apparent inconvenience was caused the sheep by the ingestion of these large amounts of ash constituents, except in the early part of our first feeding experiment, when the saltbush was fed green, but in this case the trouble was of short duration and did not recur. The crude fibre is not very abundant and has a low coefficient of digestion.

In spite of all of these good points the results of our two experiments with sheep indicate that the saltbush, when fed alone, will just maintain the animal. The results were the same whether it was fed green or in the form of hay. The leaves are not greedily eaten by the sheep; perhaps the very large amount of ash constituents present in them has something to do with this. There would seem to be no question but that in order to get the best effects out of a fodder containing 20 per cent. of protein it should be mixed with another poorer in nitrogenous substances.

This plant is supposed to grow particularly well on alkali soils. I found that it does well on soils which are considered as free from alkali, but remarkable differences seem to exist in the composition of the plant and also in that of the ash. The samples 1 to 4 inclusive were gathered from the same plot of ground; the soil varied, and we find that the proteid content varies by five per cent. Again, one of the California samples contained 11.64 per cent., while the South Dakota sample carried 18.87 per cent., and our last sample used in the digestion experiment contained 20.60 per cent., an extreme difference of 11.90 per cent., which, I believe, to indicate

the ability of this plant, to vary in composition according to the soil conditions under which it may be grown. Climate has nothing or very little to do with this case, as two of the samples referred to were grown at this Station.

The high content of mineral matter—ash—leads directly to the inference that the plant makes a heavy draft on the soil, especially as the plant is not only rich in ash but also yields a heavy crop. The California Experiment Station cut at the rate of 5½ tons of hay per acre, (Cali. Ex. Sta. Bul. 125, p. 6.); others give a much larger crop (ibib. p. 7), where a green crop is given as approximately 30 tons, which would not be less than 6.5 to 7 tons of hay. The hay made from this saltbush carries about 17 per cent. of ash, the sand and dust deducted. This would mean the removal of from 900 to 1,200 pounds of lime, magnesia, potash and soda from each acre of land, of which, according to my analyses, from 288 to 384 pounds would be potash and from 252 to 336 pounds would be soda. There would further be removed from 64 to 83 pounds of phosphoric acid.

These facts are of interest principally to show that the plant is a very heavy feeder, more so indeed than most useful plants. While alfalfa is a heavy feeder, removing from 180 to 200 pounds of mineral matter with each ton of hay, it is far behind the saltbush in this respect, which will remove not far from 340 pounds with each ton of hay. This matter is of little interest so far as this bulletin is concerned, still it may be worth while to consider the composition of the ash of this saltbush.

ANALYSES OF THE ASH OF THE AUSTRALIAN SALTBUSH, *Atriplex semibaccata.*

	Alkali Soil.	Alkali Free Soil.	Alkali Soil.*
Carbon	Trace	Trace	
Sand	3.82	10.93	16.24
Silicic acid	1.24	4.60	
Sulfuric acid	3.46	2.14	2.64
Carbonic acid	16.88	21.51	....
Phosphoric acid	3.54	3.43	2.80
Chlorin	20.80	5.82	24.33
Potassic oxid	14.37	16.02	11.42
Sodic oxid	23.79	14.85	35.39
Calcic oxid (lime)	8.54	13.27	5.79
Magnesic oxid	6.94	6.20	3.23
Ferric oxid	1.23	0.90	1.38
Aluminic oxid	Trace	1.21	1.95
Aluminic oxid	Trace	1.21	1.95
	104.75	100.99	105.39
Oxygen equivalent to chlorin	4.69	1.31	5.35
	100.06	99.68	100.04

*California Bulletin 105, p. 13.

The most striking differences are shown in the chlorin content. The California sample shows that almost one-fourth of the ash is represented by chlorin, while our sample, grown upon good, upland soil, considered free from alkali, shows that this element—chlorin—makes up only one-sixteenth of the ash. Again, the California sample shows three times as much soda as potash, while our upland sample shows more potash than soda. It is further clear at a glance that our sample grown on alkali soil approaches much more nearly to the composition of the California sample.

The plant takes up under the conditions of alkali soils a large amount of salt. The data given in the California bulletin show that it takes up, in round numbers, 800 pounds of salt, sodic chlorid, in producing five tons of hay. Our data show that it used about 600 when grown on alkali soil and only 163 pounds when grown on good, non-alkali soil. This hay, with its large percentage of ash, does not seem to be detrimental to animals, but it is an entirely open question whether the large amount of salt may not be a necessary condition for the perfect development of the plant.

The object of this bulletin is to present the facts concerning this plant so far as they are known for the consideration of our ranchmen, who need a forage plant which will produce from a fair to a good yield of reasonably good hay with but little rainfall. This plant seems to promise to fulfill all of these requirements. Though the California Station experimented with saltbushes for eighteen years and unreservedly recommended this one, the *A. semibaccata*, as the most promising one, and the Department of Agriculture at Washington distributed, if I am no mistaken, seeds of this plant, Director Wickson writes me that "the acreage in California is exceedingly small, probably not more than a small fraction of one per cent. of the amount which was contemplated." There may possibly be found an explanation for this failure of the plant to come into the popularity that its free growth and good composition seems to entitle it. They may have some other fodder which supplies their needs and is of easier culture, or easier to handle, but in those sections of our State which are of late years filling up with settlers and where the older inhabitants have had to have recourse to the Russian thistle, the coarse sand grass of the plains, or to the native saltbushes, this plant is worthy of a trial. It will not grow without any care. Even the native saltbushes are not always abundant, and this one will probably be no different except it receives intelligent planting and some nursing.

The following facts seem to have been established concerning this plant: First, when once established it will endure drought and

even make a good crop with less than five inches of rainfall.* Second, that stock will eat it or readily learn to eat it either green or as hay. Third, that it will produce very heavily under favorable conditions. Fourth, that it will, when fed alone, maintain the animals, and even better results are claimed for it. Fifth, that the hay is rich in protein, as rich or even richer than alfalfa. Sixth, that its coefficients of digestion are excellent, except for the fat or ether extract and crude fibre. Seventh, that it has no injurious effects on the animals even when they have no other fodder with it.

The following facts, however, remain, that it has not become popular, and that when fed alone it does not produce the results that its composition and coefficients of digestion would seem to warrant us in expecting. There is no reason for questioning the advisability of feeding something relatively richer in carbohydrates along with it, if they are at hand, but if they are not stock will live on this fodder alone.

RUSSIAN THISTLE.

On a preceding page reference was made to the use of this plant as a fodder. No one in any irrigated section would think of growing either the saltbush or thistle for forage. Press Bulletin 5 of this Station, by J. E. Payne, reprinted as part of Bulletin 64, reports the use of the Russian thistle in sections where other fodder cannot be raised readily. Some men report that it makes a good fodder, but other men of good judgment who have had experience in feeding this hay do not confirm the claim. Payne views it as an emergency forage. One man told me that he had tried it, feeding forty head of cattle, with very unsatisfactory results, and that many of his cattle died. As it is used to some extent in sections where there is no other available forage plant, or better where the supply of other and better plants is insufficient, I have studied the plant to a limited extent. There are only a few analyses of this fodder available. The following will serve to show the composition of the plant at various stages in its development:

ANALYSES OF THE RUSSIAN THISTLE.

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
ut June 12*.....	....	22.01	2.20	18.46	17.94	39.39
ut June 26.....	....	18.79	1.84	17.72	23.19	38.46
ut July 12.....	....	14.30	1.14	9.11	30.82	44.63
mall and tender†....	....	20.32	3.91	17.78	16.27	41.72
o thorns	....	21.21	3.18	14.71	22.45	38.45
horns out	....	18.25	2.97	13.45	21.62	43.71
ipe	....	13.75	3.77	12.34	37.70	32.44

*California Bulletin 105.

*Iowa Bul. 26, p. 28, three samples cut June 12, 26, and July 12.

†Report Minnesota Exp. Sta. 1894, p. 35, four samples also Bul. 20

Green thistle ‡.....	....	30.10	1.59	20.62	12.92	34.77
Hay	....	22.98	1.36	12.37	18.98	44.31
Hay	....	20.19	1.79	11.88	18.11	48.03
Green	....	29.29	1.79	19.16	12.21	37.55
Hay discolored	....	15.54	1.59	9.42	23.58	49.87
Hay, Fort Collins....	5.29	13.77	2.24	10.89	29.66	38.15

The last sample was gathered when the plants had thorns on, but were still green and succulent.

The ash constituents in this plant are high and indicate that it is a heavy feeder, especially on potash, as the analyses show. The composition of this ash seems to vary considerably.

ANALYSES OF THE ASH OF THE RUSSIAN THISTLE.

	Akron, Colorado.	Fort Collins, Colorado.	Minn.* Sample Plants Small.	Minn. Sample Thornes Well Out.	Minn. Sample Ripe.
Carbon	3.95	none			
Sand	11.25	0.90	1.93	2.43	3.95
Silicic acid	0.73	0.49			
Sulfuric acid	2.73	2.64	1.52	1.62	4.39
Carbonic acid	21.56	22.38	19.28	20.25	17.34
Phosphoric acid....	3.70	3.19	3.49	4.00	3.11
Chlorin	4.29	13.51	....	....	1.56
Potassic oxid	28.68	44.10	26.82	31.21	27.37
Sodic oxid	0.85	0.82	9.16	4.25	12.46
Calcic oxid	16.44	9.42	26.37	24.55	22.39
Magnesic oxid	5.52	5.17	9.66	7.66	5.56
Ferric oxid	0.89	0.27	0.86	1.01	0.85
Alumnic oxid.....	0.52	Trace	....	....	....
Manganic oxid (br)	0.07	0.04	....	....	....
	101.16	102.93			
Oxygen equivalent to chlorin	0.98	3.04			
	100.18	99.89.	99.09	96.63	98.97

We find the phosphoric, sulfuric and carbonic acids given in the Minnesota analyses as phosphates, etc. I take it that this is a misprint and that the corresponding acid is intended.

These analyses do not agree at all. The chlorin, for instance, varies from 1.56 to 13.51, and my own samples differ by more than nine per cent. The only thing clearly evident is that this plant is a heavy potash feeder.

*Report Minnesota Experiment Station, 1894, p. 36.

‡Report Kansas State Board of Agriculture, 1902, p. 25, five samples.

Bulletin 136 Jan. 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Dewberry Growing

BY

O. B. WHIPPLE

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

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Dewberry Growing.

By O. B. Whipple, B. S.

As Colorado is noted for its variety of climates so is it remarkable for its diversity of products. We are fast learning that certain localities are best adapted to growing particular kinds and even varieties of fruit and the grower is to be commended who adapts himself to his environment and becomes a specialist. We have our recognized peach sections and we might, if we do not already, have our recognized dewberry sections. Probably the dewberry growers of the Plateau valley, a valley tributary to De Beque, Colorado, and the Grand Valley proper, have gained a greater name for their dewberries than have those of any other part of the state and it is the purpose of this bulletin to outline their method of culture for the benefit of those similarly situated. Here, dewberries are grown at an elevation varying from 5500 to 6500 feet and surely finer berries cannot be grown anywhere. Lower elevations, at least in the western part of the state, are not well adapted to the culture of this fruit on account of the extreme heat of summer, the berries are short and seedy as compared with the long luscious berries grown at higher altitudes. The fruit seems to develop best where the maximum temperature is not above 90°, and probably maximum temperature is a better guide than elevation. It must not be inferred, however, that dewberries may be grown in all localities favored with such summer temperatures; severe, drying winters may prove too trying for dewberries in localities otherwise well adapted to their culture.

That dewberries may be grown profitably in localities where the maximum temperature often runs above 95° in the shade, during the picking season, is proven by the returns from a plantation near Fruita, Colorado, in the season of 1908. Here three-quarters of an acre produced 345 crates of berries and brought a gross return of over $650. The berries were not as large as those grown at higher elevations. The variation in season in different localities is better understood when we say the picking season at Fruita extended from July 7 to August 1, while at Plateau City, Colorado, Mr. Baldridge's patch was at the height of its season on August 1.

Although Card in his "Bush Fruits" seems to doubt the value of the dewberry and suggests that its place may yet be taken by some early ripening blackberry, there is no danger of such a change of favor in Colorado. It ripens earlier than most blackberries and the plantation is much more easily handled. It is in a class by itself and unfruitfulness due to lack of proper fertilization or other causes is a misdemeanor of which the Colorado dewberry, in suitable locations, is not guilty. At present, however, the acreage of dewberries that can be profitably grown will no doubt be limited by the short life of the berry in transit and hence the accessible markets. As yet we have not learned to ship the fruit any great distance—it may almost be said that they must be on the market within thirty-six hours after picking. Unless by

some means we can lengthen the life of the fruit in transit, over-production may easily take place. For this reason it is encouraging to think that the industry is new and that probably much is to be learned about the proper handling of the fruit for shipment.

Quite a variation in season may be found in different sections and altitudes, and all dewberries do not necessarily come into competition.

Soils and Locations. In its wild state the dewberry is found growing on comparatively light sandy soil and if this is significant it would suggest that our sandy mesa soils are the best adapted to its culture. Yet in Colorado, the dewberry, like our tree-fruits is grown on almost any kind of soil. Considered from the standpoint of both ease of culture and adaptability, however, sandy soils free from rock or gravel are best adapted to dewberry growing. Since the plants must be covered for the winter, and as they are generally covered with the soil about them, any considerable amount of gravel or rock is undesirable. In the introductory remarks it has been suggested that the dewberry does not develop well in a hot climate and here it may be said that much may be gained by choosing a northern exposure upon which to set the dewberry patch. The best growers recognize this as an important point, the fruit not only develops better but the vines get through the trying days of winter and spring with less injury.

Propagation. The dewberry may be propagated by layering the tips or from root cuttings. In fact the plants are so easily secured that one may generally get them from his neighbors plantation more easily than from a nurseryman. If plants are required by the wholesale a good plan is to plow a furrow along the row, place the tips of the runners in this and turn a light furrow back upon them; the tips must be actually covered. This work should be done before the opening of the picking season in most altitudes, and the plants will be ready for next spring's setting. Deep cultivation that will disturb or break large roots will cause many new plants to start. If an old bed is to be discarded, a good crop of plants may be secured by thoroughly plowing and working down the bed in the spring allowing the young plants to spring up from the broken roots the following summer. Root-cuttings, from roots the size of a lead pencil, may be taken in the fall, stored in moist sand over winter and planted out in nursery rows the following spring. If these root-cuttings are well cared for during the winter and planted three inches deep in a good soil, kept well moistened, a fair percent will produce plants. Root-cuttings taken in the spring and planted in the same way will also give fair results. The dewberry does not sucker as freely as the blackberry, neither does it root as readily from root-cuttings.

Preparation of Land for Planting. In an irrigated section the first step in the preparation of land for any crop is proper leveling, low spots where water settles or high spots difficult to irrigate materially cut down the dewberry yield. Best stands are secured when the ground has been deeply plowed, well worked down and pulverized; no doubt fall preparation is advisable for spring setting.

Planting. The majority of our dewberry beds are from spring settings but many of our experienced growers seem to be of the opinion that fall setting would prove as satisfactory and would bring quicker returns. I see no reason for not setting in the fall, the plants would necessarily be quite tender the first winter but could be well protected and should suffer no injury. Planting in the fall should be done in early September and spring planting as soon as the ground can be worked. As to distances for planting there is still some dispute, but, if the plants are to be allowed to grow prostrate, setting 5' x 5' seems to be the most satisfactory system. They can be pruned accordingly and cultivated either way. If grown on a wire trellis, rows six feet apart with plants three feet in the row would no doubt be a better system. When planted in the young orchard, the distance can be made such as to best utilize the space. There is no particular objections to planting dewberries in the young orchard but the grower is to be cautioned about crowding the trees and advised that in most cases it is not a crop for the old orchard.

For planting, the ground is furrowed out one way and cross marked. The plants are dropped in the furrow at its intersection with the cross-mark, and partially covered with the foot. The furrow is turned back, the plants straightened up, the soil firmed about them, and the job of setting is completed by running water down the row. As with any other plant, the top should be cut back at setting time to offset the loss of roots in digging.

Cultivation. The cultivation of the dewberry patch should not be unlike that for any other bush-fruit. It should be well-cultivated in the early part of the season to keep down the weeds and conserve the moisture. Cultivation stops at the opening of the picking season and is resumed again at its close, continuing until the end of the growing season. Since deep cultivation which disturbs or breaks the roots tends to start objectional plants in the middles, the early cultivations and possibly the later ones should be rather shallow. If the plants are allowed to run for the purpose of being trained on a trellis, cultivation must be in one direction; when checked equal distance each way the general plan is to keep the middles open only one way. While it may be possible to overgrow the plants by continual cultivation, it is better to counteract this by withholding water rather than by discontinuing cultivation. Good cultivation is no doubt conducive to vigorus, but not necessarily to rampant growth.

Irrigation. There are really no tricks in irrigating dewberries. The ground should be kept moist and in good condition during the early part of the growing season. The young plants will stand a good deal of water the first season. During the picking season it is the common practice to water after each picking, just a light surface watering. This supplies the roots with the needed moisture to swell the berries to good size and by keeping the surface of the ground moist the berries ripen better, there is less loss from the drying of the fruit. It would be a good plan, no doubt, to try to induce early maturity of the canes by withholding water after the close of the picking season. In localities where the winter snowfall is not great the dewberry patch should be given a late fall irrigation.

Fertilizing. The grower of dewberries cannot expect that the plants will continue bearing good annual crops without fertilization. If properly cared for, there seems to be almost no limit to the duration of the plantation. Good stable manure is one of the best fertilizers for our Colorado soils. It may be applied in early spring before uncovering the plants and the uncovering process as well as early cultivations will help incorporate it

with the soil. Frequent light applications are preferable to heavy and irregular ones, as they tend to promote more uniform growth and yields.

Pruning. In western Colorado at least, dewberries are allowed to grow prostrate, growers say it is too expensive to trellis them and it might be added that the present system seems highly satisfactory. No doubt, under certain conditions, trellising would be advisable but surely could not increase the yield any considerable amount. Where the plants are grown on a trellis, they receive no summer pruning as a rule; the new canes are allowed to trail on the ground under the trellis while the fruiting canes are tied to the wires. The only pruning the plant requires—unless it be a clipping back in August to induce early maturity—is cutting out the old canes in the fall or spring and shortening the new ones to three or three and one-half feet. A two-wire trellis is generally used, the top wire being about three feet from the ground. The training of the dewberry without the trellis requires a little more care in pruning but saves the labor of tying up and allows of early cultivation either way. The first pruning consists in tipping the new growths when they have attained a length of twelve or eighteen inches, the canes then stand upright above the old wood and the tips may be mowed off with a sickle or large knife It is important that this pruning be done at the right time, do not wait until the canes are longer and then cut back to eighteen inches or weak lateral canes will be the result. This early pruning forces out lateral canes and thus increases the bearing surface as well as stiffen the lower part of the cane, making it support itself better. The general practice is to prune the second time just before picking begins. The main object of the pruning seems to be to get the new wood out of the way of the pickers. At this time the lateral canes forced by the first pruning are cut back to two or two and one-half feet, they should be left long enough to shade the old wood and the fruit, yet short enough to be easily lifted by the pickers. This pruning must not be delayed too long as it starts new growth which should have time to mature, at its best it is not satisfactory and it is probable that the growers will yet learn to avoid this pruning. The third pruning is administered the following spring, and consists in removing all old canes and shortening-in the new canes that may have grown too long. There seems to be no reason why this pruning may not be done before covering in the fall other than that the foliage makes the pruning more difficult.

Winter Protection. The dewberry is not hardy in most parts of Colorado, consequently the canes must be covered during the winter. The difficulty seems to be that the canes do not mature well before frost and they tend to dry out during the dry winter weather. Just before the ground freezes it is the common practice to bunch together the canes from each plant and cover them with a light covering of soil. Where the vines are allowed to grow together in the rows, they are kicked apart, strung out, and covered in the open middle. The covering of dirt need not be heavy, just enough to hold the plants down throughout the winter. There is danger in covering the plants too deep, especially if they carry heavy foliage, as the canes are liable to become heated. The bare bases of the canes should be well covered. Most growers cover with a shovel, one man covering about 1500 plants in a day. The vines must be uncovered in the spring before growth starts. The canes are not injured by light spring freezes, and the new growth that starts while the vines are still covered is either knocked off in the process of uncovering or is killed by the hot sun afterward.

The canes may be lifted with a fork and the dirt scraped away from about the crown, leaving the rest of the leveling to the cultivator.

Picking. In growing dewberries on a large scale one of the serious problems is that of securing pickers. The average picker will pick from five to seven crates a day, and this means that it will take from eight to ten average pickers to pick an acre per day. The general practice is to pick every third day, and the large patch may be divided so as to furnish the pickers employment every day.

The pickers must at least wear a glove on the hand used to lift the vines and most of them wear a glove with the tips of the fingers removed on the picking hand. Some growers supply the pickers with a twelve-basket carrier, or two if the pickers are fast and able to carry them. Others advocate the use of the regular shipping crate holding twenty-four baskets. A bale may be made of heavy wire bent in a way to clamp into the grooves that serve as handles in the end of the crate. Of course crates used to pick in cannot afterwards be used as shipping crates. The deck boards and baskets for the second tier are carried along and placed in position when the first tier is filled. In this way the picker carries a full crate in one hand and at the same time does not expose them to the sun for any length of time. A piece of heavy cloth large enough to cover half the crate may be tacked by two corners across the center of the crate and used to shade one end of the crate while the other is being filled. The pickers should be made to grade the fruit, and the best way is to have them put the culls in certain boxes and pay them for picking these the same as first-class fruit. This plan provides a place for fruit the picker gathers and hates to throw away because it fills up. Dewberries should be picked when a full glossy black. Berries which have gone beyond this stage and turned a dull or more ashy color are too ripe to ship. The cull box is the place for over-ripe, dry, and poorly colored berries. Ripe berries start mould if packed for shipment.

Dewberries should not be picked when moist, as after a heavy dew or rain. Pickers are paid by the crate, thirty cents, if they pick part of the season, and thirty-five cents if they finish the season. If the grower does not protect himself in this way, some of the pickers will leave him when picking gets poor.

Packing. Since dewberries were first grown in Colorado several styles of packages have been used but the crate known as the Doube-deck Raspberry Crate and now commonly used comes as near perfection as any. This crate holds twenty-four pint veneer boxes, twelve in each deck. When the bottom tier of boxes is in place a second bottom similar to the first is dropped in—the ends of the crate being supplied with grooves to support it—and the second tier rests upon this. The crate is arranged in a way to give perfect ventilation, and good ventilation is essential in shipping dewberries. The general practice is for the pickers to sort the berries and then all the packer has to do is to see that the boxes are full and not overfull, and possibly throw out a few defective berries overlooked by careless pickers. When packed and covered the crates should be picked up end to end, preferably under an open shed, and allowed to thoroughly air out before shipping. If possible, it is a good plan to let them air over night and ship in the morning; unless well aired out the fruit molds in transit. Shippers should also insist on the car being well ventilated; icing only seems to aggravate molding.

As in the packing and grading of any fruit, the berry grower has an opportunity to establish a reputation for his product. So long as the number of dewberry growers is limited and the matter of grading and packing is not an association problem, the individual grower should put up a pack that he is not ashmed of and stamp his name and address upon the crate. Mr. Jas. P. Baldridge, the veteran dewberry grower of the Plateau Valley, and to whom I am indebted for much valued information and help in the preparation of this bulletin, has adopted this plan and is known the state over for his dewberries. He could dispose of the entire output of his five-acre patch through mail and telephone orders but prefers to let a Producers' Association handle the bulk of the crop. Such a plan relieves the grower of much responsibility and associations are better collectors than individuals. The man who receives the fruit from the pickers and crates it for shipment should always be on the lookout for poorly colored, defective, or over-ripe berries. Pickers often pick small, dry berries and these should not be allowed to go in a first-class pack. The packer also sees that the boxes are well filled but not overfull.

Varieties. In spite of the fact that most eastern growers advise interplanting of different varieties to insure perfect fertilization we see no need of taking such precautions in Colorado. The Lucretia is practically the only variety grown in our best dewberry sections, yet we see no tendency toward imperfect fertilization. The variety seems perfectly satisfactiry and there seems to be little occasion for testing new ones. The Lucretia stock varies considerably and could no doubt be improved by proper selection. From the literature on the subject it would seem that only one other variety, the Mayes, gives promise of equaling the Lucretia.

Insects and Diseases. So far the dewberry in Colorado is exceptionally free from the attacks of insects or plant diseases. No insects have been reported as doing serious damage. The common leaf spot of the ramblers has been observed in only a few plantations, and here it seemed to be doing no serious damage. The work of this parastic fungus is first indicated by purplish spots which appear on the leaves. These spots later dry out and turn a lighter color and show a few dark pustules in the center. Still later the diseased tissue may drop out entirely giving the leaf the appearance of having been riddled with shot. Should it become necessary to spray for this it could no doubt be controlled with one of the standard fungicides.

Yields and Returns. A dewberry plantation in good bearing will yield from three hundred to four hundred crates of berries per acre. Mr. Baldridge's patch, set on four and one-half acres of ground but with enough plants for five acres, was set in 1903. In 1904 it yielded 125 crates of berries, in 1905, 1800 crates; in 1906, 1800 crates and in 1907, 2000 crates. It would probably be hard to give a satisfactory estimate of the cost of production of dewberries. The crate costs the grower 27 cents and picking 35 cents per crate, plus probably 5 cents for overseeing and crating the fruit. Estimating the cost of production at $1.00 per crate this would leave 25 cents per crate for other work. With a yield of 350 crates per acre this would mean an allowance of $80.50 for other labor, irrigations, cultivating, pruning, covering etc. Possibly this is not high enough; but granting that the cost of production is $1.25 per crate, which is surely high enough, the grower still nets a return of $1.00 per crate. At present the average price paid for dewberries has been $2.25 per crate F. O. B. the nearest shipping point.

The Loganberry.

In some of our best berry sections, the Loganberry is sharing popular favor with the dewberry. This berry is supposed to be a hybrid of the red raspberry and the Western dewberry, and it resembles both. The fruit is almost identical in shape with the dewberry, possibly a little shorter, but has the color and flavor of the raspberry; in foliage it resembles the raspberry and in growth it has a trailing habit midway between the two. It has the advantage over the dewberry in that the canes stand up better, but it is not generally conceeded to be as good a producer. When fully ripe the berry is a little softer than the dewberry but apparently ships well, and so far it has sold for the same prices. Comparison of flavors is largely a matter of personal likes and dislikes, but in the raw state it is doubtful whether its flavor is as pleasing to most tastes as is that of the dewberry. Its flavor is improved by cooking and it makes a very fine sauce. As it is grown in a limited way, it is impossible to say whether it will prove as popular when grown more generally, or whether the demand is limited. It surely deserve a place in the home garden at least.

Its culture is practically identical with that of the dewberry. The plant is a little stronger grower and may profit with a little more room. It is possible that the first pruning may be omitted, but, on the other hand, this pruning may materially increase the yield by multiplying the number of fruiting canes. The fruit is a little harder to pick on account of a tendency for the calyces to cling to the fruit. It is picked, packed and handled for market as is the dewberry.

Bulletin 137 Jan. 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Some Animal Diseases

[POPULAR]

BY

Drs. GLOVER, BARNES and KAUPP

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

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Some Animal Diseases.

BY

Drs. Glover, Barnes and Kaupp.

Introduction.

This publication is intended as a *bulletin of information* and in no sense a scientific treatise of subjects under consideration.

According to recent statistics there are something over $50,000,000 invested in livestock in the State of Colorado. There is probably no place where livestock of all kinds is generally more healthy. The loss we suffer is not so much from the ravages of any one or several contagious diseases, as it is from the aggregate loss from innumerable things, such as accidents, colics, pneumonia, poisonous plants, etc. Most of this loss is attributed to either ignorance, or carlessness and is preventable.

This constant loss of valuable animals, to the farmer and stockman must be figured as just so much taken from the profits, and in the end means success or failure of the enterprise. The most casual observation at once suggests the importance of education of the farmer and farmer boys, on the care and management of livestock, the recognition of the more common diseases, and vastly more important than all —how to prevent them.

This bulletin of information deals with a few conditions that seem to be of the most importance to stockmen of the state, just at this time. In it we hope to throw out a few hints that will be easily understood and of real practical value.

Sore Mouth Disease of Pigs and Calves.

(*Necrotic Stomatitis.*)

By Dr. Geo. H. Glover.

During the last fifteen months this disease has been a veritable scourge among hogs in Colorado. Calves and other species of animals have not been much affected. The name "sore mouth disease" is rather misleading because the disease is not always confined to the mouth.

Cause: The cause of this disease is a germ and nothing else can produce it, although improper food, dirty and unsanitary pens are in a way responsible (predisposing causes) for it. To grow a good crop of corn it is necessary to cultivate the crop and furnish other favorable conditions. In the same way, having the germs of disease planted, the disease is sure to develop if conditions (filth, exposure, lack of exercise, etc.) generally favorable, are existing. Experience has shown that the saying—"Anything is good enough for a hog," is a great mistake. Within the last year many examples have come under our observation where farmers taking exceptionally good care of their hogs have escaped and others in the same neighborhood have lost all the small pigs they had from this disease.

The germ of disease getting into a slight wound or sore anywhere on the body, or in the stomach, or bowels, will grow and destroy the

tissue until it has produced a deep cavity. It may be the jaw bone or end of the tongue, tips of the ears, or perhaps has involved a large area of the stomach. This is not the worst of it perhaps, for while the germs are growing, they secrete poisons (toxins) which are absorbed and poison the whole body.

Symptoms: When this disease gets among the herd the pigs from a few weeks up to a vear old are seen (first one or two) to be unthrifty; on examining the mouth, there is usually found a deep sore, (not always), the back is arched, there is a loss of appetite, and within a few days the pigs are dead. Examination of the carcass after death will always reveal the presence somewhere on the body (inside or out), of deep seated angry looking ulcers.

Prevention and Treatment: To allow this disease to spread among the herd is little short of criminal.

If your hogs are healthy and your neighbors hogs have this disease, see to it that you do not purchase any animals from him and thus infect your own herd. The farmer himself may carry the infection on his boots. Clean out the pens frequently, scrub out the feed troughs, and keep them well supplied with clean bedding.

If this is too much trouble, then be prepared to take the consequences. If the hogs have the disease it can be stopped with little expense of time and labor.

How to Proceed: First; isolate the healthy from the sick animals, dip all the healthy pigs in a barrel of the following solution: potassium permanganate 1-oz. to one gallon of water. Place all of these healthy pigs that have been dipped, by themselves in clean new quarters, and dip them once a week. Second; the sick pigs may be treated by burning out any sores with lunar caustic and dipping them like the others. Usually however, it will be better to destroy them and burn the carcasses. Third; *disinfect the premises.* Rake up all the litter and burn it. Whitewash the fence posts, plough the pasture, scrub the feed troughs in boiling water, burn sulphur in closed buildings. It may be necessary to follow this proceedure a second or even a third time. Success at the start is the reward of thoroughness with which every detail of the work of isolation and disinfection is carried out.

Lip and Leg Ulceration or Necrotic Dermatitis of Sheep.

By Dr. Geo. H. Glover.

This is an infectious disease of sheep which has recently appeared in the West. It is caused by the same organism as *sore mouth disease of pigs.* This germ (*bacillus necrophorous*) not only affects pigs, calves and sheep but may attack any warm blooded animal. People have been affected.

Before this germ can invade the body it is necessary for the skin or mucous membrane to be broken; the germ once having gained entrance into the tissue, begins its special business of tissue destruction, in whatever part of the body it has found lodgment. This organism is no doubt the cause of many of the persistent sores on the feet and legs of horses, sometimes on the neck and shoulders. In sheep the

legs and lips are more commonly affected. There is not much inflammation surrounding the diseased area, only deep, angry looking ulcers that will not heal and gradually grow larger. This condition of the lips of sheep is not to be confused with a sore mouth condition which often appears in sheep and lasts for a few days when they have first been put on heavy feed.

In case of infectious dermatitis the feet are especially liable to become sore, between the claws or just above the hoof; the mouth will become so sore that they can not eat and very seldom do they recover without treatment.

Treatment: If the sheep be watched carefully and upon the first appearance of the disease the ulcers are cauterized deep with a stick of lunar caustic, the disease may be checked. If the disease has progressed far, the ulcers penetrating deep into the flesh and the system poisoned by the toxins of the germ, it is better to destroy them and burn the carcasses.

If the disease has made its appearance in your flock proceed to clean it up in exactly the same way as is recommended in the preceeding article on sore mouth disease of pigs.

Poisonous Weeds.

By Dr. Geo. H. Glover.

The weed has been defined as a plant out of place. We have in the arid West probably a greater variety of plants, certainly a greater variety of poisonous weeds than can be found anywhere else in the United States. The different loco weeds easily take first place from the standpoint of the disaster wrought to the livestock interests of the State. The Experiment Station is doing everything possible with its limited means to investigate the different poisonous plants on the open range, and with the view especially of trying to determine some means of lessening the heavy mortality by prevention, antidotes, etc.

LOCO WEEDS.

About four years ago the Colorado Experiment Station undertook a co-operative investigation of the loco weeds in conjunction with the U. S. Department of Agriculture.

This much has been determined, as reported by the Bureau of Plant Industry, Bulletin No. 121, part 3.

Symptoms of Loco Poisoning: "The principal symptoms are the lowered head, rough coat, slow staggering gait, movements showing lack of muscular coordination, sometimes more or less paralytic symptoms, a general diseased nervous system, and in the later stages of the disease, extreme emaciation."

Pathological Changes: "The principal pathological changes are pronounced anemia of the whole system, diseased stomach walls, and in acute cases a congested condition of the walls of the stomach, while in chronic cases there are frequently ulcers. Generally speaking, locoed cattle have ulcers in the fourth stomach. There is an excess of fluids in the various cavities of the body. This is especially noticeable in the epidural space of the spinal canal. Here the effusion is more or less

organized, presenting the appearance of a gelatinous mass, which is especially abundant in the lumbar region and about the exits of the spinal nerves. In most locoed females the ovaries are found in a diseased condition.

Cause: According to the report of Albert C. Crawford, pharmacologist, poisonous plant investigation, "It is the inorganic constituents, especially barium, which are responsible for this poisonous action, at least in the plants collected at Hugo, Colo."

Ridding the Ranges of Loco Weeds: "In regard to the possibility of killing the weeds, it was found that this could readily be done in the case of fenced pastures. This is especially feasible with Astragalus mollissimus, because it occurs in comparatively small patches. Aragallus lamberti has a wider distribution, but it is not at all impossible to destroy this weed when in pastures. There seems to be no way of ridding the ranges of these weeds, however."

Treatment: "In regard to the second phase of remedial work, it was found that locoed cattle can in most cases be cured by a course of treatment with strychnine, while locoed horses can generally be cured by a course of treatment with Fowler's solution. The animals under treatment must not be allowed to eat the loco weed and should be given not only nutritious food, but, so far as possible, food with laxative properties. To this end magnesium sulphate was administered to correct the constipation which is almost universal among locoed animals. It should be noted, too, that magnesium sulphate may serve to some extent as an antidote to the poison.

It may be added, in regard to the question of immunity, that loco poisoning comes on in a slow and cumulative manner, so that there is no possibility of animals becoming immune."

LARKSPUR.

Barring the several species of loco weed, by far the most important poison weed in the State is three or four species of larkspur. The loss to the State from this source is something like $50,000 per annum.

In almost every instance where we have been called upon to investigate the poisoning of live stock in the mountainous sections of the State it has proved to be some species of this deadly family. The entire plant is poisonous up to the time that it flowers. It then not only becomes unpalatable to most animals, but loses a large part of its poison. When in flower it can easily be distinguished from all other plants by the color and shape of the flower, which has a projection on the back side, hence the name larkspur. All the different species have this characteristic shape, the blue or white flower, and so far as we know now all the different species are poisonous.

The poisoning occurs mostly in the spring when the plant is young, and during or immediately after a snow or rain storm. Cattle and sheep are much more frequently affected than horses. The animal usually starts for water, may fall down several times, stagger to its feet and try to keep going. Letters have been received frequently from different sections of the State describing a heavy loss through poisoning and accusing an unscrupulous neighbor of having willfully placed

poison in a spring or water hole. The reason why the spring is thought to be poisoned is because there is sometimes a little misunderstanding between the neighbors, and the fact that the cattle have been found dead near the spring has naturally lead to the supposition that the neighbor was wreaking vengeance by purposely poisoning his neighbor's stock. The real reason is, of course, that the animals as soon as they become distressed will start for the nearest water hole to drink and are often found adjacent to it.

The most active poison in the plant is called *Delphinine,* and in its action is very similar to aconite, depressing the heart's action and producing great weakness, and in many cases there is extreme bloating, the same as from alfalfa. Many antidotes have been tried, but only two appear to be of real benefit. The chemical antidote, potassium permanganate, has given results that are surprisingly satisfactory. The advantage in this drug is that it changes the poison and renders it harmless before it has been absorbed into the system. It is a most valuable antidote for poisoning by several of the alkaloids. With some little inconvenience it can be carried in the saddle bags by the cow boy and be the means of saving some valuable animals. If you wish to try this, go to your drug store and have put up a number of powders each composed of 30 grains of potassium permanganate and 30 grains of aluminum sulphate. When a poisoned animal is found it should be given one of these powders (regulate dose by the size of animal) in a quart bottle full of water. The other antidote is atropia sulfate, which is to be given with a hypodermic syringe which stockmen usually use for vaccinating their calves against blackleg. This antidote is used after the poison has been absorbed into the system. The tablets can be secured at any drug store, and carried along with the hypodermic syringe and a little bottle of water, and may be used by cow men while riding the range. If the animal is badly bloated it should be punctured high up on the left side with a knife, or better with a trocar and canula. This allows the gas to escape from the paunch, and is often sufficient treatment of itself. Bleeding seems to be the general practice and while this is not generally believed in now-a-days, either in the practice upon the human or the lower animals, yet in the case of larkspur poisoning it is claimed by stockmen to give beneficial results; if so, probably by relieving the passive congestion. Melted lard given at the very start would no doubt be of some benefit by mechanically preventing the rapid absorption of the poison. Never give tobacco, aconite, or anything that will tend to depress the animal. Stimulants are indicated, such as whiskey, ammonia, camphor, etc.

Next in importance to loco and larkspur is *wild parsnip* and *Death Cama.* Copies of Bulletin No. 113, "Larkspur and Other Poisonous Plants," may be obtained on application to the Experiment Station. The leaves of the wild cherry, monkshood, sage, skunk cabbage, ergot, sorghum, kaffir corn, and the rubber plant under certain conditions, mouldy hay, potatoes, carrots, etc., all come in for their share of the annual mortality in our domesticated animals.

A knowledge of the identity of poisonous plants, and conditions

under which they are most dangerous, would of itself be a great help to the stockman.

Blackleg.

By Dr. C. L. Barnes.

Blackleg (Symptomatic Anthrax) is a disease of young cattle and is caused by a germ. Most diseases of livestock are attributable either directly or indirectly to bad care and management, but this disease invariably strikes down the calves that have received the best care and are in the best condition.

Symptoms: One of the first symptoms noticed is the sick animal remaining away from the herd, usually lying down and not chewing its cud. If the animal is forced to move it appears stiff, usually in one fore leg. If this leg and shoulder be examined closely, it will be found that the muscles are swollen and tense. This swelling gradually increases as do all of the symptoms. The peculiar crackling sound, emitted when the hand is rubbed over the tumor is caused from gas which has accumulated under the skin.

If the swelling be lanced, a dark, frothy, bloody fluid runs out which swarms with blackleg germs. Death usually occurs in from six to forty-eight hours after the first symptoms are noticed.

The Season of Greatest Loss: Blackleg occurs in all seasons of the year. Reports from 1,656 stockmen show that May and June, and September and October are the months when the greatest losses occur. It would seem that it is greatest in wet seasons, for the sole reason no doubt, that feed is better in the wet season, and this is conducive to thrift and increases the susceptibility to the disease.

Treatment: As to treatment there is none. Practically all animals contracting the disease die. Our only hope is in the prevention.

Prevention: The fact that young cattle in a thriving condition are more susceptible, has led to the general belief that anything that will deplete the condition will act as a preventive, accordingly, various means of depletion have been tried such as chasing the animals, reducing the feed and water, bleeding, physic, seton through the dewlap, etc. This sort of thing however is very discouraging to the man who has been striving to keep his cattle growing, and besides when the disease has once appeared in the herd, such measures will not check it.

Vaccination: Vaccination will positively prevent blackleg; this is proven in laboratories where animals that have been vaccinated refuse to take the disease by inoculating them with the virus of diseased animals. The reason that some have not had satisfactory results from its use is that either the vaccine is not good or has not been properly given. Again occasionally a man will wait until his calves begin to die before vaccinating, and if they continue to die, he blames the vaccine. In such cases the calves were infected before vaccination and his efforts were and always will be in vain. Those who have made a regular practice of vaccinating every spring and fall and have exercised care in the work have generally reported excellent results.

Glanders.

By Dr. C. L. Barnes.

If your horse has glanders, or if any of your animals are sick or dying with what appears to be a contagious disease, it is your privilege and duty to notify the State Veterinarian at the Capitol Building, Denver, who will visit your place without expense to you.

Glanders is one of the oldest diseases known, its contagiousness being recognized as long ago as the seventeenth century. Glanders is caused by a specfic germ (Bacillus mallei) and affects horses, asses and mules. The goat, cat and dog sometimes contract the disease from living in stables with glandered horses. Pigs may contract the disease by inoculation. Cattle and chickens are immune. The disease attacks the mucous membrane of the nose, and may extend to the windpipe and lungs. When the lymphatic glands of the surface of the body are affected, the disease is known as farcy. The germs are found in the discharges from the nose and the farcy buds. The disease is transmitted to other animals, including man, by inoculation through wounds or mucous membranes. There are also many additional ways in which animals may be affected, such as common drinking troughs, feed boxes, mangers, hitch racks, harness, and any equipment used around an infected stable.

Symptoms: Glanders may occur in the acute or chronic form, or it may attack the surface of the body in the form of farcy. The acute form of glanders begins with a chill, high fever, the mucous membrane of the nose is at first hot and dry, and soon there is a watery discharge, which later becomes bloody. Nodules and ulcers form on the mucous membrane of the nose and discharge pus. These changes in the nose may take place in two or three days. There is also an abundant diarrhea, and the urine contains a large quantity of albumen. The patients become very weak and rapidly lose flesh.

The first symptoms of chronic glanders oftentimes are not easily recognized owing to the absence of distinct symptoms in the first stages of the disease. The first noticeable sign of the disease is a watery discharge from one or both nostrils, which later on become sticky and of a yellowish-gray or yellowish-green colored pus mixed with some blood coming from ulcers on the inside of the nose, and more particularly on the partition separating the nostrils. These ulcers are generally star shaped, and they may extend so deeply into the septum as to cause perforation.

When glanders affects the skin (farcy), one of the main symptoms may be the swelling of a joint with engorgement of the limb and nodules may form along the line of the lymphatics. These nodules vary in size from a pea to a hen's egg, and have a tendency to soften and discharge pus, after which they heal rapidly. New nodules may form, following the same course as the previous ones.

Manner in which Glanders may be distinguished from Distemper: In both these diseases there is a discharge from the nose. In distemper it is usually from both nostrils, while in glanders, as a rule, it is

from one side only. In glanders there are the characteristic ulcers formed in the nose, which, after healing, leave a star shaped scar. In distemper there is a doughy swelling between the branches of the lower jaw, which is hot and painful and interferes with the swallowing and causes the horse to carry his head forward. This swelling has a tendency to soften, break and discharge pus; while in glanders the swelling along the lower jaw is painless and the swollen glands remain distinct and cord-like. Also, in testing with mallein the glandered horse has a large, painful swelling at the point of injection of the mallein, which will not occur in the animal with distemper.

Prevention: All glandered animals should be immediately destroyed and not allowed to come in contact with healthy animals through stables, common drinking troughs, harness, or any other stable equipment. All suspicious animals should be isolated and cared for independently of healthy animals, until examined by a competent veterinarian. Infected buildings should be disinfected with one to five hundred corrosive sublimate solution, and a week later the process repeated. Then in two weeks after the second disinfection all woodwork should be whitewashed. Forage and litter in infected stalls should be burned. Attendants caring for suspicious animals should exercise precaution against contracting the disease.

Glanders is practically an incurable disease, therefore it is not advisable to treat it.

In doubtful cases of glanders, the *mallein test* is given. This test should only be given by a qualified veterinarian and until it is satisfactorily determined whether a suspicious case is, or is not glanders, the animal should be kept apart from all other horses or mules. Remember that the disease is occasionally transmitted to the human and is incurable in man or beast.

Foot and Mouth Disease.

By Dr. B. F. Kaupp.

Foot and mouth disease has made its appearance in the United States twice during the past ten years. The first time in 1902, an unexpected outbreak occured in Massachusetts, Rhode Island, New Hampshire, and Vermont. By prompt action of the U. S. Department of Agriculture, Bureau of Animal Industry, this outbreak was quickly stamped out. All animals found affected were destroyed and either burned or buried deeply in the earth after first covering with lime.

Recently the disease has been discovered in a much wider district involving Maryland, Pennsylvania, New York and Michigan. By strict quarantine, the destruction of all animals found affected and by thorough disinfection it is hoped that the disease will be entirely eradicated.

It is necessary that this country be kept free from Foot and Mouth disease as otherwise an embargo will be placed upon American cattle, thus a great financial loss to the stock producing West.

In European countries where the disease has existed for a long time, the number of animals that die from this disease is only about

five percent. The greatest loss is as follows: In dairy cows the owners suffer the loss of milk from four to six weeks. Cattle lose flesh, due to high fever, and inability to eat, due to the fact that the sores and vesicles (water sacs) in the mouth make it impossible for them to eat. Owners can not dispose of the sick animals.

After the animal has been exposed to the disease for about one week it will be taken by a chill which is followed by fever. In about two or three days small vesicles (water sacs) will be noticed in the mouth, on the borders of the lips and tongue. These vesicles contain a yellowish thin fluid. The redness about the feet which is followed by the formation of vesicles like those in the mouth takes place soon after the formation of those in the mouth. Thick saliva dribbles in rope-like strings from the mouth.

Animals which have recovered from the acute attack are found to be seriously injured. Many of them will lose the hoofs from their feet. Others are chronically lame. Abscesses may form in the udders of cows giving milk. Pregnant cows may abort. Many are so injured constitutionally that they become emanciated and of no value.

In conclusion we may consider that while the loss from death due to the acute attack is perhaps only five per cent, the total loss in death, loss in milk, loss to fattening cattle, etc., will amount to perhaps close to fifty percent.

The only thing is to keep the disease out of the United States. Prompt action by the Federal Authorities who control interstate commerce, destruction of the animals, thorough disinfection, and strict quarantine are the only sane measures.

Hog Cholera.

By Dr. B. F. Kaupp.

The losses from hog cholera in the various states amounts to many millions of dollars annually. The spread of contagious diseases through the central stock yards and by cars and boats not disinfected, a condition which existed prior to the establishment of inspection by the Federal Bureau of Animal Industry, resulted in the contagious diseases existing in this country, (among them hog cholera) becoming wide spread.

The real germ of hog cholera is a microscopic organism which passes through the finest of filters, a germ which has not been discovered. We either have not discovered a suitable staining fluid or our microscopes are not powerful enough to see it. This filtrate from which all other germs have been taken out produces the disease.

The Bacillus Cholerae Suis or the secondary invader producing this disease collect in the capillaries of minute blood vessels and these rupture, cause a small red or hemorrhagic spot. Upon examination after death these small hemorrhages are found in the kidneys, over the outer surface of the bowels and inner surface of the abdomen and thorax, etc. An observation of the skin shows red patches due to small hemorrhages into it. In young hogs the spleen (melt) is

often noted to be inflamed, (splenitis), it often is three or four times its normal size. The fat is somewhat of a lemon yellow. The lymph glands (kernels) are noted to be swollen and hemorrhages in them. Pneumonia may be present. The bone is black. When the small intestines are opened ulcers are found on the inner surface.

Symptoms: In the more severe cases the animal may die in a very few hours after the first symptoms are noted.

If the disease in the individual assumes a milder type there is first seen signs of fever, chill, not caring to move, will lie apart from the balance of the herd. There will be a loss of appetite, the bowels may be normal, or constipated, or diarrhea may be present. If pneumonia is present there will be noted an increase in respiration. The eyes are congested in the earlier stages, later a watery discharge and a gummy, adhesive yellowish or whitish accumulation in the corners of the eyes. The animal may cough, is now tucked up in the flanks and has a jerky respiration commonly called "thumps."

Treatment: The first measures should be a thorough cleaning up of the houses and yards. The hog troughs should be kept thoroughly clean and disinfected. The task of thoroughly disinfecting the hog houses, yards, troughs and fences is not an easy one but the free use of a spray gun with five per cent carbolic acid, bichloride of mercury one dram to each gallon of water, or creolin one per cent will do much good in the way of disinfection.

Medicines which are given by the mouth or in the feed are of little or no value. Many so-called "hog cholera cures" are put on the market, but they are fakes pure and simple. It is an easy matter to get testimonials. Passification of the mind may do as a "placebo" but if the hogs get cholera they will need something other than talk. There is one method of producing immunity against hog cholera and that is by serum injection. For many years after the discovery of the bacillus cholerae suis the manufacture of hog cholera serum was attempted by the United States Department of Agriculture through its Bureau of Animal Industry.

This serum is made by hyperimmunizing the hog by taking a hog that has passed through the disease and injecting this pig with a quantity of virus from a hog sick with cholera and in this way producing in this hog a greater resistance, and as a result the serum from the blood of this hyperimmunized hog will produce a greater resistance against the disease in another individual and make it proof against cholera.

The Bureau of Animal Industry has been conducting extensive experiments along this line in Iowa for several years and have perfected this method of treatment. They have asked the Experiment Stations of the various States to cooperate by establishing the hog cholera experiments departments upon their farm so as to manufacture and furnish at a minimum cost all serum needed within the State. The serum perhaps costs a trifle more than those serums which can be produced by using the horse as the hog does not furnish a great deal of blood.

Bulletin 138 January 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

SOME BACTERIAL DISEASES OF PLANTS

[Information Bulletin]

BY

WALTER G. SACKETT

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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SOME BACTERIAL DISEASES OF PLANTS

By WALTER G. SACKETT

FOREWORD

It is the purpose of this bulletin to call attention to some of the more common bacterial diseases of plants which are either present in the State or may be expected in the future, with the hope that the old adage, "To be forewarned is to be forearmed," may be of some avail. With one exception, the diseases here treated are well known in the Eastern and Central States, where they have caused immense losses to gardeners and fruit growers. Where remedies are known, they have been suggested, but it is the deep regret of the plant pathologist that for the majority of bacterial diseases no efficient treatments have been discovered and prevention is the only hope.

While the climatic conditions of Colorado may be said to be on the whole unfavorable to the development of diseases in plants, especially fungus troubles, the fact remains that there are some localities which have suffered heavily from causes traceable to bacteria. Nature has blessed this State with conditions which afford all that could be desired toward the natural prevention of bacterial diseases; the dry air, the limited amount of rainfall and the abundance of sunshine, all combine against the growth of germs.

The soil of Colorado is comparatively new so far as agricultural practices are concerned, and with the change in its character and fertility, brought about by continued cropping, we shall expect to find many of our cultivated plants becoming more and more susceptible to the attacks of microorganisms.

With the introduction of new plants, new varieties of old plants, foreign seeds, and strange nursery stock, it is not at all improbable that previously unheard of diseases will make their appearance.

Again, as the farming communities become more thickly populated and more new land is cleared and brought under cultivation, the danger of plant diseases spreading from farm to farm is greatly increased.

Plants and trees, like human beings and the lower animals, are affected with contagious diseases which spread from individual to individual, from field to field, and from ranch to ranch in precisely the same manner as any contagion is communicated from one member of a family to another. The more densely a city is populated, the greater is the danger from the spread of disease and the more stringent must be the laws which govern the sanitation of

that city. Quarantine must be established or an epidemic is sure to follow. Just so with diseases in our fields. It should behoove every farmer to see to it that his field is free from infection and to compel his neighbor to be equally vigilant.

The diseases treated are:

Bacterial Disease of Alfalfa, Page 4.
Pear Blight, Page 6.
Soft Rot of the Sugar Beet, Page 14.
Black Rot of Cabbage, Page 15.
Blight of Potato, Tomato, Egg Plant, and Tobacco, Page 19.
Bacteriosis of Beans, Page 21.
Wilt of the Cucumber, Cantaloupe, and Squash, Page 22.

BACTERIAL DISEASE OF ALFALFA

PRELIMINARY REPORT.

In November 1906, Prof. Paddock* called attention to an alfalfa disease occuring in certain parts of Colorado, which was different from any previously described malady, and which, from all appearances, was not related to either leaf spot or mildew. Gross examination of the affected stems and roots and subsequent microscopic examination satisfied him that in all probability the disease was of bacterial origin. During the past summer, 1908, a careful study of the disease has been undertaken both with field and laboratory studies, and a technical bulletin is now in preparation, describing both the diseases and the causal organism. Our present investigations have confirmed the preliminary work of Prof. Paddock and have shown the cause of the disease to be due to a germ of the bacillus type.

DESCRIPTION OF THE DISEASE.—At a distance, the disease can be recognized by the short, sickly growth of the first crop and the marked absence of that rich, deep green color and succulent appearance of a thrifty stand. Many of the plants do not get over eight inches to a foot high by the time of the first cutting. A close examination of the stems shows them to be shriveled and blackened for two to three inches up from the ground. The infection seems to attack the plants next to the soil and to work up the stem. As the disease progresses, it produces a watery, semi-transparent, brownish appearance of the tissue which turns black with age. By running the thumb nail along the stem, it is possible to scrape up under the delicate surface skin a little yellowish, watery blister, the content of which is a sticky, stringy liquid, yellow in color, and alive with bacteria. This liquid frequently oozes out on the stems

*Press Bull. 28, Colo. Expt. Sta.

in little bead-like droplets and there hardens into small, amber-colored scales. Again it appears to dry uniformly over the surface, or just beneath it, and there produces a dark brown, resinous surface, which blackens with age. Such stems are very brittle and easily broken, which fact makes it almost impossible to handle the crop without an immense amount of shattering.

The leaves attached to the diseased part of the stem usually show the watery, yellow color at the base and especially in their tiny petioles. The leaves on those parts of the stem which are blackened are always dried up, yellow, and extremely brittle. The stipules at the base of the petioles are yellow and brittle, and show the disease before their corresponding leaves.

One year old plants exhibit blackened areas in the crown and black streaks running down into the tap root. As the plant grows older this blackening increases until the whole crown is involved, and either the crown buds are destroyed or the root is no longer able to perform its functions, and death follows.

So far as our present observations go, the disease appears to run its course with the first cutting, and those plants which have sufficient vitality throw out a good growth for the second and third cutting. Strange as it may seem, there is little or no trace of the blight during the remainder of the season, but in the following spring an aggravated outbreak may be expected. The disease apparently does not kill many plants the first year, but they begin to die after the blight has been prevalent more than one season, and after two or three years so many of them may be missing that the stand is practically worthless.

At present, we are at a loss to explain satisfactorily why the first cutting, only, should be attacked, unless it is that by pasturing cattle on the alfalfa field during the winter, the constant tramping splits open the crowns and bruises the young, tender shoots so that during the first irrigation, soil containing the disease germs is washed into this injured tissue. The weather conditions at this time of the year are, as a rule, unfavorable to a rapid, vigorous growth of the plant, and it is probably in a hyper-susceptible condition. This explanation is borne out, first, by the fact that the disease has not been observed to occur until after the first irrigation; and second, by the fact that since no cattle are allowed in the field after the first cutting, the young crown buds of the second crop have received no mechanical injuries through which they might become inoculated. Again, the plants themselves are in a more vigorous, resistant condition at this season of the year.

Future experiments alone will demonstrate whether it will be possible to prevent the disease upon the first cutting by keeping stock off the land during the winter and early spring, and by so doing

eliminate mechanical injury to the plants during the susceptible period.

Inasmuch as the disease seems to be clearly a soil trouble, the only practical method of controlling it is by the introduction of resistant varieties. To this end we have planted some twenty-seven different varieties of alfalfa on sick land with the hope of obtaining one or more blight resistant strains. This side of the work was begun by Prof. Paddock two years ago, and after two years' trial under field conditions, we have obtained some very promising results with two of the varieties tested. Whether these will continue in their resistance during the next few years remains to be seen.

PEAR BLIGHT. (*Fire Blight*)

A description of Pear Blight may seem uncalled for to the fruit grower who is sufficiently familiar with the malady to recognize it at first sight and to whom the mere suggestion of the name recalls immense financial losses, but to the farmer, who has three or four trees around his house for his own use and who has not had his attention called to the disease in such a material way, some consideration of the subject may be given with profit. Not only should the farmer become acquainted with the symptoms of the disease and learn and practice methods of prevention and eradication for the sake of his own trees, but also for the sake of his neighbor's orchard as well. One infected tree in the community may mean the ultimate loss of vast orchards for miles around.

Of all the diseases which affect our fruit trees, there is none, perhaps, which is so universally dreaded by the orchardist as the pear blight. While the ravages of the disease are worst upon the pear, from which fact the disease derives its name, its attacks are not confined in any sense of the word to this tree alone. Many varieties of the apple, quince, apricot and plum, together with the mountain ash, service berry and several species of hawthorne, have suffered severely from the same cause. Especial attention should be called to the part which such ornamental trees as the mountain ash and hawthorne play in harboring the germs of blight. If these trees become infected and are allowed to go unnoticed, it is obvious that it is useless to attempt to stamp out the disease in adjacent fruit trees or a nearby orchard, since a constant supply of germs will be furnished by the ornamental plants mentioned, with which to reinfect the fruit trees. If such conditions are found to exist, but one thing remains to de done—remove the offending individual bodily and burn it.

The name *fire blight* is especially good because it is at once suggestive of the symptoms of the malady. To one not familiar with the disease, it can be recognized at first sight by the brown and

subsequent blackened appearance of the young leaf tufts and flower clusters; some of the leaves may be only partly blackened, while the greater part of the blade remains green; the young twigs show a blackened, shrivelled bark, resembling very much green brush which has been only partially burned. The blight makes its appearance early in the spring shortly after the blossoms have fallen and works rapidly back from the blossom clusters an inch or more a day. It soon involves the tender, succulent twigs and may ultimately destroy the whole limb. If the diseased wood be cut with a sharp knife, a dark ring between the bark and the wood will usually be seen. This is a further indication that the tree is affected. This ring of tissue, now blackened, is known as the *cambium layer*. It is here that a rich and abundant supply of food is to be had and, quite naturally, what is good for the growth and development of the tree is equally as nourishing for the germs. So we find, upon microscopic examination, that this blackened cambium tissue has lost its normal color and appearance and instead of the cells being almost white in color with a clear, colorless liquid within, they are brownish, more or less broken, and all through this mass of broken down tissue is a straw-colored liquid, clouded with millions upon millions of germs. These germs is growing here have dissolved out the starchy constituents of the plant tissue and literally eaten up the cells to such an extent that the circulation of the plant is destroyed. The rapid progress which the disease makes is to be accounted for, in a measure at least, by the fact that the causal microorganisms have the power of very rapid movement; that is, we say they are motile. Thus enabled, they are persistently swimming about in the protoplasm of the cambium, dissolving and boring their way into new, healthy tissue where a fresh supply of food can be obtained. As the disease progresses and the smaller limbs show the infection, the tender bark may crack and a thick, black, sticky gum, alive with germs, may exude; soon afterwards the bark becomes dark colored, hardened and shrunken.

The disease makes its greatest progress during the actively growing period in the spring when the tree is putting forth a multitude of young, tender twigs and the new tissues are gorged with sap. Just such conditions as these favor the growth of the blight microorganisms, so it is easy to see why the disease is worst at this time of the year. As the season advances, the plant tissues harden, less sap is flowing, and conditions for germ life become less favorable. As a result, by the middle of summer the active progress of the blight is checked by natural causes, but the disease is still present in what may be termed a latent form. In this stage it sometimes remains through the balance of the season and, protected by the bark of the twig or limb, it may live through the winter, giving

rise to what is known as holdover blight. It is the germs which exist in this holdover blight which serve to reinfect the orchard the following spring. In most instances, however, the germs die out of their own accord during the winter and leave the whole tree or portions of it free from the infection of the previous season. Although the disease is usually at its best in the early spring, the writer has in mind an orchard in Central Ohio, numbering some four hundred trees, in which the blight assumed its most severe form about three weeks previous to picking the fruit. Up to the middle of August there were but three or four badly infected trees, and within three weeks from that time, every tree in the orchard was suffering from a severe attack. The fruit had to be picked two weeks before time in order to prevent all from being ruined by the blight.

Pear blight is variously known as pear blight, apple blight, fire blight, twig blight, blossom blight, and body blight, the name depending upon the species and portion of the tree affected. If the blight attacks the larger branches and trunk where there has been some bruise or mechanical injury, the symptoms are much the same as what is known as sun burn or sun scald. This form of the malady is known as rough bark or body blight.

It is only within comparatively recent years that we have known that the cause of apricot and plum blight is the same as that of pear blight. Prof. Paddock,* in describing the disease as it occurs on the apricot, says:

"At this time many of the fruits were attacked, the diseased areas varying in size from a spot an eighth of an inch in diameter to irregular areas that involved three-fourths of the fruit. The skin over these places soon became nearly black in color and shrunken as the tissues were consumed till the outline of the pit was disclosed. These discolored areas were always definitely outlined and bordered with a zone of watery appearing tissue usually about an eighth of an inch in width. The latter was green in color and as hard as the sound flesh.

"The smaller spots where the disease had evidently just started, invariably surrounded a lenticle, thus indicating that the disease gained entrance to the fruit through these openings.

"The injury to the twigs may be described best by saying, that they resembled closely, blighting pear or apple twigs. So far as noticed only tender twigs of the current season's growth were attacked. These were shrivelled and discolored from a few to several inches in length, and small drops of sticky fluid were occasionally found on their surface and upon the shrivelling leaf-stems. The discolored outer bark blended gradually into normal appearing tissue, but the inner bark was discolored for some distance below any external evidence of disease."

HISTORY.—The disease is by no means recent, for it dates back to the time of William Denning, who first reported the trouble from the Highlands of the Hudson in 1770. He described it fairly well and ascribed the cause to a borer in the trunk of the tree.

The oldest book on American Fruit Culture, published in 1817

*Bull. 84, Colo. Expt. Sta.

by William Coxe, gives a very accurate description of the disease. From this early date up to comparatively recent times, horticultural literature has been crowded with numerous extravagant theories of the cause of the blight. Even today we occasionally find men who hold to one or another of the old ideas. It may be interesting to know what some of these were:

1. Insects.
2. Rays of the sun passing through vapor.
3. Poor soil.
4. Violent changes in the temperature of the air or the moisture of the soil.
5. Sudden change from sod to high tillage, resulting in surplus of sap.
6. Effect of age.
7. Autumn freezing of unripe wood, which makes a poison destroying the shoots and branches the following spring.
8. Electricity in the atmosphere.
10. Fermentation of sap.
11. Absence of certain mineral matters in the soil.
12. Something in the air which is carried from place to place.
13. Fungi.

ORIGIN AND SPREAD.—In 1878, Prof. W. T. Burril, of the University of Illinois, succeeded in finding a kind of bacteria which he believed to be responsible for the disease.

The blackened twigs and sticky exudate were found to be alive with germs, which are very small plants, so small, in fact, as to be seen only with a very powerful magnifying glass such as we find in the compound microscope. Some idea of the size can be gotten when we know that it would require 25,000 germs placed end to end to make one inch.

By taking some of this gummy material, which contains the bacteria, and inserting it into a healthy twig through a small cut, it was demonstrated that the inoculated twig took the disease and that therefore it could be spread from one tree to another, or was what we call an infectious disease. It was also shown that this same gummy material from the pear could produce the disease on the quince and the apple. This experiment is very simple and can be tried by anyone who is interested in the infectious nature of the blight. It was argued by some that it was not the germs which produced the blight, but rather the gum which was injected. To meet this objection, the germs were grown in a suitable medium such as beef broth and a quantity of the pure organisms were inoculated into a healthy twig. The results were very conclusive, for the twig soon died, showing that the germs by themselves had the power of killing the plant.

The question which we now have to answer is, where does the blight originate when our orchards have never had it before? Where does it come from? It has been shown quite conclusively that it is

not carried on the wind, neither is it traceable to the soil. Ants, flies, and possibly bees may feed on the gummy material which runs out from the cracks in the diseased wood, and knowing that this exudate contains millions of germs, it is only reasonable to believe that these insects carry the disease on their feet and bodies to the healthy trees. Alighting on a delicate flower cluster, they crawl deep down after the so-called honey or nectar in the blossom and here many of the blight germs are brushed off and left in contact with the tender blossom. Through these honey ducts or nectaries the bacteria gain entrance to the plant. Once favorably situated, they multiply and move down the twig between the bark and woody cylinder through the growing layer. It is in this way that a large percentage of the cases originate. As further evidence of this method of infection, we may cite the investigations of Mr. M. B. Waite, of the U. S. Department of Agriculture, who found the germs developing in the nectar of the blossoms and also discovered them adhering to the mouth parts of honey bees after they had visited infected flowers. He further observed that, in many cases, trees which did not blossom were free from blight.

Again, the germs may gain entrance into the tender shoots through insect bites in the bark, for, although the opening may be no larger than a pin prick, myraids of bacteria can find a temporary dwelling place in this wound and may soon spread through the whole member. Lastly, the infection may enter the large limbs and trunk of the tree by some scratch or bruise in the protecting bark which has exposed the susceptible growing layer beneath to the visits of germ-laden insects.

Thus we see that pear blight is caused by a germ to which the name *Bacillus amylovorus* (Burrill) has been given, the meaning of which is starch destroying. We see that it is spread from one tree to another by different insects, and that the germs may gain entrance into the plant in any of three ways: First, and most important, through the blossom; second, through insect bites in the tender shoots; third, through mechanical injuries to the bark of the limbs and trunks of the trees.

CONDITIONS FAVORING THE DISEASE.—Although the knife is our only hope of exterminating the blight, there are undoubtedly conditions which favor the disease.

It is a matter of common observation that climatic conditions have a marked influence; warm, moist weather with a large amount of rainfall favors it, while bright, dry, cool weather tends to check it. That is, the former conditions are advantageous to the growth of the germs, while the latter are unfavorable.

High cultivation, rich soil, heavy manuring, the use of large

quantities of commercial fertilizers containing a great deal of nitrogenous material and heavy pruning all tend toward the growth of tender, succulent shoots. It is in this sort of plant tissues, gorged with sap, that the blight germs can grow and multiply most rapidly. Biting insects whose mouth parts are contaminated with the causal microbes, are most partial to these juicy shoots and leaves, and their bites often serve to infect the tree.

It is evident, then, that vigorous, healthy, rapidly growing, too well cared for orchards are more liable to the disease than others, and since these are factors which the grower can control, it is he who must strike the happy medium which will not permit the trees to suffer and yet will not give ideal conditions for the development of the germs.

PREVENTION AND TREATMENT.—The treatment of fire blight is of two kinds—the one, preventative, which aims at making the tree resistant to the attacks of the disease; the other, curative, which is intended to exterminate the harmful microbes and thus prevent their spread.

1. It is obvious, if we are to render our trees resistant to blight, we must avoid those conditions which increase the predisposition to the disease. We have already mentioned the most potent factors in the propagation of blight as high cultivation, rich manures, commercial fertilizer high in nitrogenous material, excessive soil moisture, and high pruning. In short, anything which favors the rapid growth of tender, succulent shoots should not be practiced. It is understood, of course, that these suggestions are not to be followed without reason, or the trees will suffer from troubles other than the blight. The trees should be allowed to ripen their wood, and to this end the grower must use some means which will limit the moisture in the soil. It is recommended that some good cover crop, such as oats, be used for this purpose in localities where the necessary moisture is supplied by rain and where the growing period is apt to be prolonged into the late summer because of excessive soil moisture.

In irrigated regions, where the water is entirely under the control of the grower, the problem of ripening the wood and preventing late succulent growth is a comparatively simple one. Good results have been obtained in eradicating blight from afflicted orchards by withholding water altogether for long periods and also by limiting the amount supplied to the minimum necessary to keep the trees alive.

Prof. Paddock* gives the following account of an orchard suffering with pear blight, which had not received any water for two

*Unpublished Notes

and a half years and which illustrates in a practical way what the withholding of water has done toward the eradication of the disease in a natural way:

"The writer had an opportunity of studying an orchard during the summer of 1904, which had been without water for two and one-half years. The effect of this enforced drought on checking blight was very marked, and it also showed that pear trees can exist in this location for a considerable period without irrigation or cultivation. These results would probably be the same in all of the pear growing sections of Colorado. * * * * At the time of my visit, June 25, 1904, many of the trees were still in good condition. This was especially true of the Winesap apple. The Jonathan trees were still in condition to be saved, but they were less vigorous than the Winesaps. Most of the Ben Davis trees were still alive, but the majority of them had put forth few or no leaves. About one-half of all of the apple trees of all varieties were dead, as well as most of the peach and plum trees.

"But the most remarkable, was the appearance of a block of eight-year-old Bartlett pear trees. Most of them were still in a fairly vigorous condition. Some of the twigs of the previous season's growth measured fourteen inches in length. The average of the current season's growth was about four inches, and quite a little fruit had set on some of the trees.

"The inspector, Mr. H. E. Mathews, had visited the orchard each season and he found that in 1902, blight was quite abundant in the pear trees and some of them died from its attacks. The following year there was still a good deal of blight, though there was much less damage than before. At the time of my visit, June 25, 1904, there were but few twigs in which the disease had been active that season and the germs were apparently dead. * * * * These results show that the germs of blight do not thrive in slowly growing trees and, in fact, that the disease may be eradicated by prolonged drought. They also show that pear trees will remain in good condition for a considerable period without irrigation or cultivation. But just how far this could be carried in actual pratice remains to be seen, but one cannot help but surmise that bearing pear orchards might be successfully handled without irrigation, depending upon cultivation, or lack of it to regulate the water supply."

2. With a disease working as this does in the juicy part of the stem between the bark and the wood, there is no chance of reaching the trouble by means of sprays, for, unless the chemicals come in contact with the bacteria, spraying is futile.

The knife and saw remain as the only effective remedies. We must cut out and burn all affected twigs, leaves and branches, not only from the pear but the apple, quince and related species as well, so that there will be no infectious material near by for insects to carry into the blight-free orchard. It is very essential in cutting out the diseased branches to cut well below the discolored part, as the bacteria are usually far below this region. The discoloration does not appear until after the bacteria have been at work some time, so that even if all the blackened wood were removed the seat of the trouble would not have been reached, and the germs would live on in the apparently healthy stump, soon to cause another visible outbreak of the blight. The affected branches should be cut back all the way from ten to fifteen inches below the discolored wood, and if the branch be a large one, more than one-half inch in diameter,

the cut surface should be protected from wound rots by painting. Either lead and oil paint, or shellac wash, or grafting wax may be used for this, but the lead and oil paint is cheaper and less liable to crack than the others when exposed to the sun. The question may be asked, "When is the proper time to do the cutting?" The writer would answer, "Whenever the blight appears." Trimming out the diseased parts may be done at any time in the late fall, winter and spring. The most favorable time, however, is in the autumn after the leaves have fallen, for then the blighted twigs become very conspicuous by the dead leaves still hanging to them. It is not advisable to postpone the cutting until the growing season, for at that time there is great danger of overlooking new cases which are constantly occurring owing to the lack of development so early in the season. If the entire tree is affected, there is little hope of saving it and the best procedure is to grub it out and burn the whole tree. Too much stress cannot be laid upon the complete destruction of the diseased wood, for our only hope of stamping out the blight lies in removing the source of the infection. A single twig left on the ground unburned may mean the loss of the whole orchard.

The knife and the saw used must be sterilized after each cut in order that the disease germs clinging to the instrument may not be carried to the healthy parts of the tree. This can be done by passing the knife several times through a flame, or it may be dipped into either a 5 per cent. solution of carbolic acid or a 1-1000 solution of mercuric chlorid, made by dissolving 1 part by weight of mercuric chloride in 1,000 parts of water to which 2 parts of hydrochloric acid have been added.

A careful inspection of the orchard should be made in the winter and spring before the blossom season, in order to destroy any new cases that may have developed since the previous examination.

The greater part of the blight will be eradicated by one careful winter and spring cutting, and if this be done and done thoroughly, the disease can be entirely controlled.

SUSCEPTIBILITY OF DIFFERENT VARITIES.—So far as we know at the present time there are no varieties that are entirely immune to the disease. Mr. O. B. Whipple, in charge of the fruit investigations of the Colorado Experiment Station on the Western Slope, state that among the pears grown in that locality, the Bartlett, Easter, Flemish Beauty, Clapp's Favorite, Clairgeau, Howell, and Sheldon suffer worst from the blight, and among the more resistant varieties may be mentioned the Anjou, Kieffer, Seckel, Mt. Vernon, Garber and Suduth. The most susceptible apples found in this same region are the Tolman Sweet, Peewaukee, Transcendent (Crab), Jonathan, Red Mountain, and Winter Banana.

Among the apples, the crabs in every case seem to take the disease most readily, but even here there are some which are freer from blight than others. It has been observed that the same variety in different localities and under different climatic conditions will exhibit different degrees of resistance. An earlier publication of the Colorado Experiment Station* cites one case in a certain locality where Martha and Whitney crabs were grown alternately. The Whitney trees were either all dead or dying, while not one of the Marthas was affected. However, in other localities the Marthas had succumbed to the blight.

In selecting trees we should be guided by local experience and choose the varieties which have done best in our locality.

SOFT ROT OF THE SUGAR BEET.

Although this disease has not yet been reported in this State, it is not at all improbable that it will make its appearance in due time as the acreage put out to sugar beets increases from year to year. The soft rot, as it occurs in Nebraska, was first observed in 1902 by Metcalf and Hedcock,† who have isolated the specific germ *Bacterium teutlium* (Metcalf), which is the cause of the trouble. Beets affected with the rot show the lower half badly decayed and the rotting part honeycombed with "pockets," or cavities filled with a slimy, stringy fluid, colorless and sour smelling. The vascular bundles remain intact, while the tissue surrounding them is usually consumed. The normal color of the beets differs so that it is difficult to give any hard and fast color characteristic, but when affected the tissue first shows a yellow, changing to a clay color or gray; later these colors gradually darken. In some cases beets that are badly rotted show no discoloration, while others in the early stages are very dark. Above ground the beets appear normal.

A microscopic examination of viscid liquid that fills the cavities of the rotting tissue shows millions of bacteria, which when grown later in pure culture and inoculated into healthy beets produced symptoms typical of the disease.

The germs gain entrance into the beet through wounds and abrasions in the skin, and there is good reason for believing that nematodes are responsible for many of the inoculations. So far as experimental work goes, there is no evidence that infection can take place, except through cuts or scratches in the outer surface of the root. In the field, the disease has been observed to progress most rapidly under warm and wet conditions; more mature beets are affected more severely than the younger ones, probably due to the larger amount of sugar present.

*Bull. 41, Colo. Expt. Sta.

†17th Annual Report Neb. Expt. Sta.

If the beets are stored in silos and rotting sets in, they should all be inspected and the decayed ones put in a pile by themselves, so that all will not contract the rot. Cold storage does not seem to have any influence on checking the trouble, for even at low temperatures the germs continue to grow and produce havoc. It is recommended that beets from sick soil be thoroughly sunned and dried before storing, inasmuch as the dessication and sunlight have been found to be very detrimental to the growth of the germs.

Prevention is the only remedy that can be suggested at this time. Grow beets on relatively dry ground, if possible, and plant corn or some other suitable crop on former beet ground where the excess of moisture can do no harm. Our greatest hope of controlling this disease, as well as others, is by breeding up some resistant variety and, by careful selections, secure a strain which can be planted on wet land and yet remain immune. There is no question but that such resistant varieties will be forthcoming in the near future now that the scientific world is so wide awake to the wonders of plant breeding.

BLACK ROT OF CABBAGE.

The black rot of cabbage is to the truck producer what pear blight is to the fruit grower; in fact, it may be considered far worse, for on the one hand there is only the loss of the crop, while on the other, not only is the cabbage destroyed, but, in addition, the soil on which it has been grown may be so inoculated that it will be practically useless to attempt to raise the same crop on the same field with any degree of success for a number of years. While this condition of the soil exists almost universally in the East, there seem to be exceptions to it in this State, since Prof. Paddock reports that in certain localities in Colorado he has grown cabbage successfully on land which was badly infected the previous season.

Bacterial examination of diseased plants has shown the sickness to be due to a kind of germ, *Pseudomonas campestris* (Pammel, Smith). The disease is by no means confined to the cabbage, but attacks other cruciferous plants such as cauliflower, collards, kohl rabbi, kale, brussels sprouts and broccoli. It has also been reported as occurring in turnips, rutabagas, wild radish and mustard. It is widely distributed in the United States, having been found most prevalent east of the Mississippi River. In 1901, Prof. W. Paddock reported it from Colorado. Previous to 1899, we do not hear of the black rot in Europe, but the investigations of Harding,* confirmed by foreign workers, show the disease to be wide spread and of long standing. England, Holland, Denmark, Austria and Switzerland are mentioned as constant sufferers from the malady. This

*Cent. f. Bakt. II Abt. Bd. VI., pp. 305-313 (1900).

is peculiarly interesting, since a few years back a great deal of our cabbage seed was imported from Holland and Denmark. The comparatively recent discovery of the infection in Europe is probably due to the better methods of diagnosing the disease than formerly, rather than to recent appearances of the trouble. Cabbage growers of Europe have observed it for many years, it seems, but they were accustomed to associate the cabbage worm with the rot, rather than the true bacterial cause.

The disease can be recognized by the dwarfed, one-sided growth of the plants and in some cases, failure to produce heads. Sometimes the head will rot and fall off, but this is not a necessary accomplishment of the disease, for this symptom, together with the bad smelling head, may be due to the work of other bacteria which are living on the tissue already weakened by the true black rot organism. In the early stage of the disease, the leaves show a withered, dried appearance along the margin, followed, in time, by a yellowing. The small ribs that lead to the mid-rib are usually blackened first, and ultimately the larger ones and the mid-rib succumb. On cutting across the stem of an infected leaf or sick stalk, one can see the blackened ends of the fibrous strands, known as the fibro vascular bundles, which lead from the stalk out into the leaf and supply it with water and soil foods. A microscopic examination of these vascular bundles will show the tiny tubes of which they are composed to be alive with germs. As soon as these foods and water channels are destroyed, the blade of the leaf is no longer able to get the subsistance required and dies. Diseased leaves usually fall prematurely, leaving a long, naked stalk with a tuft of leaves at the tip. The old leaf scars will show the ends of blackened strands corresponding to the diseased fibro vascular bundles in the leaf.

It has been found* that the most common method of infection in the field is through the very small water pores scattered over the blunt teeth on the margin of the leaf. It is by these water pores that a part of the soil moisture that is taken up by the root system escapes from the plant as water vapor, but if the surrounding atmosphere is very moist, there will be no evaporation and the water will be seen to accumulate in tiny droplets just over the pores. However, if the soil is very dry, even though the air is moist, we do not have these water beads formed. They can be seen frequently in the early morning on the surface of the leaves and are frequently mistaken for dew. It must be borne in mind that the air is always filled with dust and numerous bacteria, and among these there are almost certain to be the germs of black rot, especially if

*Russel—Bull. 65, Wis. Expt. Sta. Farmers' Bull. 63, U. S. Dept. Ag.

the wind is blowing over a sick field carrying with it fragments of rotting plants and infected soil. These germs are in the beads of moisture, referred to above, and finding a comfortable lodging place and abundant food and water supply, they multiply very rapidly, and being able to move about, soon find their way down through the water pores into the veins of the plant. Here they continue to multiply and work toward the stalk, leaving behind them the blackened veins and withered blades. The germs may also gain entrance by means of the bites of gnawing insects and again by way of the broken roots at the time of transplanting.

There is no question but that in many cases the plants are taken from the seed bed in a diseased condition and when transplanted into the field spread the germs through the soil, rendering it unfit for cabbage growing in the future. When the source of the infection is confined to such a limtied space as the seed bed, it is possible to sterilize the soil to a depth of five or six inches by covering it with brush and cord wood and burning it, the heat produced penetrating sufficiently deep to kill most of the surface bacteria, as well as troublesome weed seeds. This is a very common practice with tobacco growers and has met with great success wherever employed. If this is not practicable, the seed bed should be located in a new place each year and where cabbage has never been grown. It is only reasonable to suppose if plants are in a good, vigorous condition when transplanted into a "healthful" field, their chance of living is vastly greater than if sick from the start.

When stable manure is used for fertilizer, every precaution should be taken to keep infected cabbage refuse from getting into the manure, for in this way the whole heap will become infected with the rot germs and when it is spread on the field the entire plat will become inoculated. One of the worst plant disease epidemics on record was caused in this very way. The writer refers to the present watermelon wilt in North Carolina, South Carolina, and Georgia, where melon growing for the past six years has been practically abandoned by the smaller producers because of the ravages of the wilt. The only safe way to dispose of refuse is to burn it.

It has been demonstrated experimentally by Harding,* Stewart, and Prucha that the cabbage seed itself is contaminated with the black rot germs and that some of them could live over winter on the seed and become the source of infection to the young cabbage plants. They advise disinfecting the seed before sowing by soaking it in a 1-1000 solution of corrosive sublimate† for fifteen minutes,

*Bull. 251, N. Y. Expt. Sta.

†Corrosive sublimate. See preparation of mercuric chloride described under Pear Blight.

or in formalin, one pound in thirty gallons.

The removal of sick leaves in the early stages of the disease is practiced by some growers with success. Others have tried this preventative and found it to be a complete failure. The investigations of Stewart* and Harding condemn this practice and prove quite conclusively that the method is not only harmful to the plants, but also worthless. The treatment fails, they say, because,

"The removal of so many leaves checks the growth of the plants; infection occurs by way of the roots as well as through the leaves; infection may occur at the base of the leaf close to the stem and get into the stem unobserved; the germs of the disease are so widely and so abundantly distributed that it is useless to try to stamp out the disease by the removal of diseased material."

Warm days, cool nights and frequent showers seem to accelerate the rot. Smith† is inclined to think that cabbage planted late is less susceptible than that which is planted early. In selecting cabbage for producing seed the following season, care should be taken to pick out only those plants which are absolutely free from the infection.

When cabbage is to be stored over winter, the heads should be examined critically and any diseased ones rejected or kept by themselves. The room or store house must be kept cool, below 40° F., and must have uniform ventilation.

It is a matter of common observation in the Eastern States that when cabbage is grown year after year on the same piece of land, there is a notable increase in the amount of rot. In the first place, such a method is not to be recommended from an agricultural standpoint, since it violates the important principle of crop rotation, and further, if it becomes necessary, because of limited space, to continue using this land, our only hope of getting rid of the disease is to grow crops other than members of the cabbage family for five or ten years and longer. During this interim the land must be kept free from all cruciferous weeds which harbor the bacteria, especially the common wild mustard.

If possible, cabbage should be set each year on ground which has not been planted to it for some time, or which has been in sod several seasons, or else cultivated to crops which are not affected by the rot. The one important thing for the gardener to observe if he would be a successful cabbage grower, is to take the utmost care to keep his field from becoming infected, and if once infected not to spread the malady over his whole farm.

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*Bull. 232, N. Y. Expt. Sta.

†Farmers' Bull. 63, U. S. Dept. Ag.

BACTERIAL BLIGHT OF THE IRISH POTATO, TOMATO, EGG PLANT AND TOBACCO.

Dr. Erwin F. Smith,* Bureau of Plant Industry, U. S. Department of Agriculture, has shown that a single species of bacteria, *Bacillus solanaccarum* (Smith), has the power of producing a blight or wilt in a number of plants of the potato family. Among the common ones attacked may be mentioned the Irish potato, tomato, pepper and egg plant. In 1903, Dr. F. L. Stevens† and the writer published an account of what appeared to be a bacterial wilt of tobacco in Granville County, North Carolina, to which the name Granville Tobacco Wilt was given. The very recent work of Dr. E. F. Smith‡ confirms this finding and further shows the cause of the disease to be none other than the organism which produces the potato blight. Several common weeds, such as the horse nettle, jimson weed and ground cherry, are also susceptible to the disease.

The blight manifests itself in the vines by a sudden wilting, either of a part or the whole. The stems usually wither, turn yellow and finally black. Young plants appear to contract the disease more readily than old ones. By cutting across the affected stem one can see the characteristic brown or black, woody tissue in which the bacteria are at work. A section across the sick vine just at the surface of the ground, or a little below, will usually show, in addition to the blackened ring, a considerable quantity of a slimy, viscid liquid oozing from the blackened parts, especially if squeezed between the fingers. This is particularly true if the soil is rather moist. Microscopic examination shows this liquid to be swarming with the bacteria, which cause the trouble. It frequently happens in the early stage of the disease that the blackening seen in the cross section of the stem will not appear as a continuous ring, but only as one or two spots. If the vine is slit lengthwise through one of these spots, a blackened streak will usually be found running the whole length of the stem and finally out into the branch or leaf which showed the wilt. The germs appear to live in the soil and gain entrance to the plant through the root or underground stem, and once within the tissue they clog up the water tubes and later on destroy the conducting vessels so that no water can be transported from the soil to the branches and leaves and, as a result, we get the characteristic wilting. The tubers from sick plants show a distinct ring of discolored tissue a short distance from the outside of the potato.

Fungicides are of no value in treating this bacterial disease

*Bull. 12, Div. Veg. Path., U. S. Dept. Ag.
†Bull. 188, N. C. Expt. Sta.
‡Bull. 141, Part II, Bur. Plant Industry, U. S. Dept. Ag.

since the germs are inside of the plant, as well as in the soil, and so far as our present knowledge goes, there is no practical method of sterilizing soil in the field. Prevention is the only remedy. Do not use diseased tubers for planting and avoil planting on potato-sick-land as well as on land which has had diseased tomatoes or egg plants.

This disease must not be confused with the fungus blights, known as early and late blight, which respond quite readily to spraying with Bordeaux mixture. In this case, the organisms which cause the blight grow on the outside of the vines and can be easily reached and destroyed by the spraying mixture.

The symptoms of the blight in the tomato and egg plant are much the same as those for the potato. The vines wilt as if suffering from too hot sun or lack of water. Decay of the stems and branches soon sets in, resulting in the destruction of the plant.

Here, too, spraying has been found useless, for the cause of the disease is deep seated within the tissue and beyond the reach of any germicide. Insects, undoubtedly, play some part in carrying the germs from plant to plant and thus spread the trouble, but the soil seems to be the principal medium of infection. What has been said in connection with the potato may be said about planting tomatoes and egg plants on land that has had diseased specimens of the potato family.

If the disease is not too general, it is possible to control its spread by removing the dead vines with the roots from the field and burning them. It is of utmost importance that the vines be destroyed and not thrown down carelessly to start the disease in a healthy part of the field. Remember that you are dealing with a contagious disease and it is your duty to keep it from spreading. One sick vine in your field this year may mean the loss of half your plants next year. Numerous cases have been reported where soil diseases have been carried from farm to farm, up and down the road by the infected mud that adheres to the wagon wheels. The greatest care should be exercised in plowing and cultivating not to drag sick vines over healthy soil, for by so doing the disease is spread, and what might have been a mild attack is aggravated to such a degree that a general epidemic results. Tools should be thoroughly cleaned before going from an infected field into one free from the disease and, as a further precaution, they should be disinfected by washing or dipping them into a 5 per cent. solution of either carbolic acid or copper sulphate, commonly known as blue stone. It is important that the gardener's shoes, as well as those of his horse, be free from clumps of infected soil before going into a new field.

There is a common practice among some farmers of hauling

the soil that has washed down a hillside back up onto the shallow places of the farm. If this is done, one should be very certain that the hillside from which this soil has washed is free from all plant diseases, for the writer is familiar with several instances where infection has been spread over healthy land in this way.

Where no remedy can be given, it is clear that our only hope of controlling a disease is by preventing its spread. By observing the foregoing suggestions, it is believed that the most serious plant disturbances can be prevented to a great extent, or at least controlled.

BACTERIOSIS OF BEANS.

Frequently the foliage, stems and pods of the common beans, as well as the Lima bean, are preyed upon by a bacterial disease, *Pseudomonas phascoli* (Smith), known as Bacteriosis. The symptoms are such as to make it readily distinguishable from all other maladies to which the bean is heir.

There appear on the different parts of the plant, especially on the leaves, large, watery, brown patches or blisters that soon dry up and cause the tissue to become brittle and to curl, leaving the foliage ragged and good for nothing. The pods seem to furnish the best food supply for the microbes and it is here that we find the disease at its best. Small discolored spots appear at first, which spread very rapidly and produce large lesions with pink or reddish brown borders, and which have pale yellow or amber colored crusts over the affected areas. This crust is due to the accumulation of myriads of amber colored bacteria which have formed a layer over the broken down tissue. After a time the pod rots and the beans are worthless.

Warm, wet weather seems to favor the disease, for the germs grow best under these conditions, and the beans at this time produce succulent growths, which are more readily attacked. Rain and dew are doubtless agents in spreading the germs from one part of the plant to another by washing them from old lesions onto unaffected parts. Insects play an important part in disseminating the trouble, consequently any measures which tend to check these pests will aid in controlling bacteriosis. The distribution of the disease is further effected by dead vines and leaves carried on the wind; by the soil, and through the seed. New land which has never grown beans seems to be freer from the disease than old, and should always be used when available.

The seed used in planting should be selected by hand and all the lighter ones discarded, since experiments show that diseased seeds are less dense than sound ones. As yet no satisfactory method has been found which can be recommended for treating the seed to destroy the causal microbe which does not lower the viability of the seed.

Inasmuch as the germs of bacteriosis work on the outside of the plant, it is possible to reach them with a fungicide and spraying with Bordeaux mixture upon two and three-inch plants, followed by the same ten days later and again after blossoming. Dr. Halstead uses a Bordeaux mixture of the following strength: Copper sulphate, 6 pounds; lime, 4 pounds; water, 60 gallons.

Variety tests conducted by the New Jersey Experiment Station during the three years 1897-1899 with Green Flageolet, Currie's Rust-proof, Early Mohawk, Golden Wax, Extra Early Refugee and Saddleback Wax, showed the Green Flageolet the most susceptible, and the Early Refugee the least.

WILT OF THE CUCUMBER, CANTALOUPE AND SQUASH.

With the appearance of a rust resistant cantaloupe in 1905, the history of which has been published by Mr. P. K. Blinn,* one of the greatest terrors to cantaloupe growing disappeared.

There is, however, a bacterial wilt which is frequently met with on cucurbits and which has been especially severe in its ravages upon the Hubbard squash. It frequently happens that the cantaloupe and cucumber are also attacked, the greatest damage occurring early in the season when the vines are just beginning to run. This disease is easily told from all other ailments of the cucurbits in that it is characterized by a wilting of the vine, pure and simple, without any visible external causes, such as rust or leaf spot. The symptoms are the sudden wilting of the leaves and runners as from lack of water or too hot sun, the runner becoming prostrate on the ground. From two to three days usually elapse before the wilting of the whole vine is complete and it is sometimes longer. It may remain in this wilted condition for several days, after which the leaves begin to dry up and ultimately die. Usually, one runner will die at a time, beginning at the tip and working back toward the root. There is no discoloration or other injury to the leaves; they simply wilt, dry up and retain their green color for considerable time.

A microscopic examination of a cross section of a wilted runner, taken near the root, or from the root iself, will show the water tubes leading out into the wilted vine to be literally clogged with bacteria. Under such conditions, the plants can get no water from the soil and a natural wilting follows. A very simple field test, and at the same time a reasonably reliable one, is to cut off a piece of a wilted runner close to the root, cut it in two crosswise and gently squeeze the freshly cut ends between the fingers; a semi-viscid liquid will ooze out from the cut surfaces and if these be rubbed together

*Bull. 103, Colo. Expt. Sta.

gently and slowly separated, this sticky liquid will string out in fine threads an inch and a half or more in length. The juices in the healthy, normal stem do not possess this viscid nature to such a degree and this phenomenon may be taken as an indication of the bacterial wilt.

Growers seem to think the disease is worse during wet weather and just after a heavy rain, especially if the sun comes out very hot. If such is the case, it is probably due to the fact that these conditions favor the growth of the germs and bring about a more rapid distribution of the bacteria through the plant.

The microorganism which causes the disease, *Bacillus tracheiphilus* (Smith), lives in the soil, in the decaying leaves and vines of the different cucurbits and probably gains entrance into the host plant through the root or some injured spot on the runner. Plant on new land as far as possible and avoid the use of fields which have shown the infection. In all probability, wilt lives in the soil for five to ten years and perhaps longer. For this reason no squash or other member of that family, which will furnish food for the germs, should be grown on sick land during this time. While rotation with other crops is in no sense a cure for the diseased soil, it is to be strongly recommended over attempting to grow cantaloupes or squash year after year, in spite of the disease.

Careful observations have shown that when only a few vines are affected, the disease is often spread over the whole field by the cucumber beetle and squash bug, hence the necessity of destroying these insects. While no direct benefit is derived from spraying, so far as killing the germs of the wilt is concerned, good often follows such treatment, because of the destruction of insects which carry the disease from plant to plant. Since no specific remedy can be recommended and no wilt resistant varieties can be offered, preventative measures alone are left at our disposal. Where the infection is not too general and it is confined to a few hills, further spread can often be prevented by digging up the vines and *burning them.*

NOTE—It is earnestly desired that the farmers, gardeners and fruit growers of the State of Colorado will co-operate with the Experiment Station in furthering the study of bacterial plant diseases by reporting all diseases of this nature that may come under their notice, and also by sending in specimens of suspicious material for examination. Wherever possible, the whole plant should be sent, for usually root, stem and leaf are required for a satisfactory diagnosis. Address communications relative to suspected bacterial plant diseases to,

BACTERIOLOGIST,
Agricultural Experiment Station,
Fort Collins, Colorado.

Bulletin 139

February 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

PRUNING MATURE FRUIT TREES

BY

O. B. WHIPPLE

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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PRUNING MATURE TREES*

O. B. WHIPPLE

INTRODUCTION.

Many and varied are the excuses offered by the man who owns an unpruned orchard; he is ashamed of the neglected trees and tries to justify himself by advancing what he considers, or more likely what he tries to persuade himself, is a good reason. One holds that pruning is little short of sacrilege, contrary to the laws of nature; another tells of his fond recollections of childhood and what excellent fruits he picked from the old apple tree, pruned alone by nature; another says it does not pay, and in his particular case it does not, for the chances are that the orchard is neglected otherwise. The only excuse that has any semblance of justification is that of ignorance, and that does not excuse the man who makes no attempt. Nature's object is the production of seed with provision for its distribution, and she is satisfied when a cherry is produced with enough flesh to attract some fruit-loving bird that may, perchance, drop the seed far from the parent tree. Man grows the fruit for its fleshy parts, and tries to improve these parts, as much by placing the plant in a more favorable environment, as by plant breeding and selection. The man who has the fond recollections of childhood would no doubt find them only childish fancies, as did the man who returned to his childhood home and tried coasting, he would be disappointed. The man who cannot afford to prune, cannot afford to grow fruit, and the man who does not know how to prune must learn; the principles are not complicated.

PHYSIOLOGY OF PRUNING.

To be an intelligent pruner one must know something of plant physiology. He should know the effects produced by pruning at different seasons of the year, how to make a cut that will heal most readily, and the influence of pruning on the fruit bearing habit of the tree. It may be said that in Colorado the fruit grower prunes at his leisure, but luckily this conforms pretty closely to the proper season, when looked at from a physiological point of view. It is generally conceded that pruning during the dormant season incites wood growth, while pruning during the growing season promotes fruitfulness; and, since our trees tend to overbear, it is logical for us to prune largely during the dormant season.

Although it is said that pruning during the summer season may encourage the formation of fruit buds on tardy bearing varieties, it may have the opposite effect, unless done at the proper time,

*This bulletin is supplementary, to Bulletin No. 106, by Prof W. Paddock, which deals with the pruning and training of young trees.

and may cause late growth and unfruitfulness. To give the desired results one must summer-prune shortly before the season of growth ends; earlier pruning starts new growth, while late pruning gives no results. The benefit derived from summer pruning seems to depend upon the ability of the pruner to prune at a time to bring about early maturity. In an irrigated section where soil conditions are easily controlled, the same end may, no doubt, be more easily attained by proper manipulation of the irrigation water.

Both the season at which the wound is made and the character of the cut have an influence upon the healing process. The pruner should remember that all food material capable of healing a wound is taking a downward course through the inner bark and that, to heal well, a wound must be in a position to intercept the downward flow of sap from foliage higher up. When a limb is to be removed entirely, the cut should be at the union with, and parallel to the surface from which the limb arises. Where limbs are to be headed-back they should be cut to a side limb and not to a bare stub. Wounds naturally heal best when made at a season of the year when growth is most active, but, with the possible exception of wounds made in early winter and subjected to a long season of drying, the season at which the wound is made has no important bearing upon the healing process. The grower who has a small orchard that will permit of such a practice, should delay the pruning until as near the opening of the growing season as possible.

The influence of pruning upon the fruit-bearing habit of the tree has been briefly mentioned, but the following pages will show how a fruit-bearing habit may, to a certain extent, dictate a course in pruning. The fruits with which this discussion has to deal have two general types of fruit-bearing; from terminal fruit buds and from axillary fruit buds. The first type of fruit bud is well represented in the apple and pear, and the latter in the stone fruits. Trees which produce axillary fruit buds are naturally more prolific and require severe pruning as a means of thinning the fruit. In fact, a system of pruning under which the tree with axillary fruit buds would thrive, would cause the apple tree to overgrow to such an extent that it would be rendered almost barren. The point may be more fully illustrated by comparing the peach and the cherry. Although both develop axillary fruit buds they differ in their fruiting habits; the fruit buds of the cherry are seldom found on the stronger growing new wood, and severe pruning, as practiced on the peach, would throw much of the strength of the tree into the production of strong wood that would carry very few fruit buds. We have said that in the apple the type of fruit-bearing is from terminal buds, yet, many varieties develop axillary fruit buds. Varieties which develop axillary fruit buds and bear terminal fruit buds on young

spurs all tend to overbear, and require severe pruning. So to a certain extent one can decide for himself how much to prune by observing how the tree bears its fruit.

TREATMENT OF WOUNDS.

The argument in favor of dressing wounds is that it prevents decay and checks evaporation, both of which might interfere with the healing process. While in our arid climate the first is hardly applicable, the second should probably be doubly important. Yet, the matter of dressing wounds is not so important, but that work improperly done is worse than no treatment. A good lead paint is one of the most satisfactory dressings yet found. Rather a thick paint should be used, and careless daubing of the surrounding bark should be avoided. Grafting wax is a good dressing, but is rather expensive and difficult to apply. Other materials have been used, some successfully and some disastrously, and the grower is to be cautioned about experimenting; better stick to materials known to be safe and efficient. Growers often overdo the matter and waste time treating small wounds. Surely a wound less than one and one-half inches in diameter is not worth bothering with.

These suggestions apply to wounds made by the careless cultivator, as well as those made by the pruner. Unsightly wounds and permanent injury may often be avoided by proper treatment of trunk wounds. When the body of the tree is injured the ragged edges of the bark should be pared off to sound tissue and the whole injury covered with paint or grafting wax. If promptly done, this prevents drying out of the tissues, and new bark will readily form, except on parts where the outer wood cells are actually destroyed, and in time this will grow over. Wrapping the injury with cloth, or if it is near the ground, mounding earth up over it will often answer the same purpose.

PRUNING TOOLS.

Every pruner should be furnished with good tools; good tools encourage him to do good work. This does not necessarily mean that he must have every tool on the market, many of them are useless; it does mean, however, that the axe and a dull saw have no place in the catalogue of pruning tools. The pruner needs a good saw, a good pair of light shears, a pair of heavy shears, possibly a good heavy knife and, of course, a good ladder. Two common types of saws are found on the market. The common saw with teeth on both edges is a good, cheap one and will answer the purpose in many cases. The various makes of the swivel saws are much handier, however. The blade is stretched between swivels and can be turned to any angle with reference to the frame. It is well adapted to close work in the crotches of the tree. This type of

saw can generally be bought for three dollars. The blades are not so frail as they look and seldom break, if properly handled; they can be replaced at a cost of fifty cents. It is really the best type of pruning saw and should be more universally used.

A good type of hand shears is indispensable for light work. Various makes are on the market; buy the one that appeals to you. A pair of heavy shears is almost as essential; they take the place of the saw in many cases and will do the work in less time. They are used in heading in limbs where the saw can hardly be used; the peach pruner finds good use for them. They work well on limbs up to one and one-half inches in diameter. The only objection the writer has to this tool is that the pruner sometimes gets careless and leaves stubs. There is a type of heavy shears on the market that has two cutting edges instead of one, but it seems to do no better work. The pruner finds very little use for a knife in pruning mature trees and seldom carries a special pruning knife. Several types of the long-handled tree-pruners are on the market, but they are of little value in the orchard. The pruner should be close to his work, and with a good ladder and short-handled tools he will do better work.

SUGGESTIONS FOR PRUNING AS APPLIED TO SPECIFIC PLANTS

THE APPLE.

With the young orchard well grown, the pruner has probably solved the most difficult problem in the pruning of the apple orchard; the principles involved in the pruning of the old orchard are not complicated. Nearly all of our standard commercial varieties of apple tend to overbear in Colorado, and one of the first objects of the pruner should be to overcome this tendency; the more prolific the variety the heavier the pruning. To be an intelligent pruner one must also acquaint himself with the habits of growth of the different varieties, as well as habits of fruit bearing. Upright-growers will require pruning to spread them, and straggling-growers such heading in as will make them grow more upright. The head should be kept reasonably open and well supplied with fruiting wood throughout. The idea of the open head, however, can be overdone. (Fig. 1.) Limbs that interfere or are liable to form bad crotches should be removed and the main branches headed in as the tree indicates the need by overbearing or by weak growth. Moderate annual prunings are always to be preferred to heavy pruning at irregular intervals; these heavy prunings tend to upset a regular bearing habit and may bring on an "off-year." However, if it should become necessary to employ drastic measures in pruning the neglected orchard, do not be afraid to do it, but do not make the mistake of selecting an "off-year" in which to do the heavy pruning.

A discussion of the amount of pruning required by different varieties could almost as well be introduced as those on the pruning of different kinds of fruit trees. Yet, the growth of the tree, and necessarily the pruning, depends much upon soil conditions; and, while it might be possible, it would hardly be safe to lay down definite rules for the pruning of any particular variety. Both the Winesap and Missouri (Pippin) may be classed as prolific varieties that require sereve pruning. The Jonathan, at the age of eleven or twelve years, almost invariably begins to grow spindling in the top and requires frequent cutting back to keep the tree in a thrifty condition. Figure 3 shows a Jonathan tree well headed-in, with stocky growth, while Figure 4 is of a neglected tree of the same variety, of the same age. These willowy limbs bear small leaves and an abundance of apples that rarely come up to size, and the liability of such neglected trees breaking down under a load of fruit is well shown in Figure 2. Figure 3 shows how sprouts are largely avoided by cutting to side limbs. Varieties that bloom heavily but set very few fruits should be treated as varieties that overbear; prune them heavily during the dormant season. Varieties that refuse to develop fruit buds should not be pruned excessively, during the dormant season at least. Summer pruning is supposed to incite fruitfulness, but does not always give uniform and satisfactory results. Such varieties may be forced to fruit more easily by withholding water in midsummer, or better still, plant them on a light soil; poor bearers are nearly always strong growers, and very often a shy bearer on heavy soil is prolific on a gravelly hillside. The Yellow Newtown is a striking example of a variety of this type. The growth and fruiting habit of the tree, we will see determine largely what treatment it shall receive at the hand of the pruner. While pruning may not take the place of thinning entirely it may be employed as a means of correcting the faults of alternate bearing and of overbearing.

PRUNING THE APRICOT.

In the general growth and fruiting habit of the tree the apricot occupies a position between the cherry and the peach. The fruit buds are developed in the axils of leaves on both shortened spur-like twigs and the stronger growing new wood. These fruiting spurs of the apricot differ from those of the cherry in that they develop no true terminal buds. The apparent terminal of the new growth is a lateral bud and may be either a fruit bud or a branch bud. It is generally a branch bud, but it is not uncommon to find weak spurs bearing only fruit buds, and such spurs with no branch bud to continue their growth must perish at the close of the fruiting season.

The general plan of pruning the apricot will resemble that fol-

lowed in pruning the peach, although, as a rule, it should be hardly as severe. The young tree is a strong grower and must be put through about the same course of training as the young peach. This strengthens or stiffens the frame work and develops a broad, low-headed tree. Normally the tree does not grow as much new wood as the peach, and it is often possible to do the majority of pruning by simply heading in the strong growth. The pruning should be sufficient to keep the fruiting wood growing thriftily and the tree well within bounds. While to a certain extent pruning reduces the labor of hand thinning, it will not take its place entirely. If properly thinned, the apricot will stand much neglect as regards pruning, but proper pruning is a matter of economy. As the tree grows older it will need more severe pruning to force new fruiting wood in the center. The absence of fruiting wood in the center of the carelessly pruned apricot tree is even more pronounced than in the neglected peach tree. The top should be well spread and the fruiting area of the head maintained near the ground.

While the season for pruning the apricot in Colorado generally extends through February and March, summer pruning is quite extensively practiced on the Pacific coast, where the trees are headed in as soon as the crop is harvested. This starts the smaller laterals into stronger growth and they develop an abundance of fruit buds. Limited observations of the same system employed in our climate suggest that it may not be without merit here. While this late growth is inclined to be immature and may suffer from severe winter freezing, it is more desirable from the standpoint of late blooming. Fruit buds on this immature wood open from four to five days later than those on mature wood. This may frequently be an advantage in localities where late spring frosts are not uncommon. The advisability of such a practice has not been fully demonstrated and is given only as a suggestion.

THE CHERRY.

The man who objects to pruning, vowing homage to nature, should grow cherries, for there is no fruit tree of which it may be said that nature is a more efficient pruner. In fact, it is a common impression among fruit growers that the mature cherry tree needs no pruning. This condition of affairs, however, is more largely due to indifference on the part of the markets than to an inability to get results from pruning. When competition becomes more keen, fancy grades of cherries will gain in popularity and, as in the growing of other fancy fruits, pruning will be found expedient.

With the cherry the fruit is borne on one-year-old wood and mostly on short growths, or spurs. An examination of the spurs will show that they differ from those of the apple in that they carry

Fig. 1.—An exaggerated type of open head; a waste of fruiting space in a Colorado apple tree.

Fig. 2—A tree allowed to grow at will. Ruined by a heavy crop of fruit. It was not overloaded for it matured its crop, but the fruit was all near the tops of the long arms.

Fig. 3—Jonathan tree well headed-in and stocky. Such a system of pruning is necessary with the mature Jonathan.

Fig. 4—A neglected Jonathan. The leaders are long and willowy and the tips are loaded with fruit spurs. The top of these leaders develop small leaves and set a large crop of fruit that rarely comes up to size. All these leaders should be cut back to strong laterals. A candidate for the same fate as Fig. 2.

Fig. 5.—A five-year-old Elberta peach tree. Almost perfect. This tree should not be allowed to grow much higher.

Fig. 6.—A four-year-old Elberta. Good form; has made a good growth with fruiting wood near the bottom as well as in the top.

Fig. 7.—The same as Fig. 6 after pruning. Plenty of fruiting wood still left, and a good framework for a productive tree. In about one more season it will have reached the limit or height. It will broaden out a little yet if it is properly pruned in the top.

Fig. 8.—A seven-year-old peach tree getting too high. Notice how the fruiting wood is being smothered out below. About two more years of such pruning and it will be like the tree shown in Fig. 11. Severe pruning in the top will yet save such a tree without cutting down the yield in any one season. This tree has been spoiled largely because the pruner did not have the room to properly spread it.

Fig. 9.—Type of tree similar to that of Fig. 8, showing about how such a tree should be pruned. Could have been cut back a little more severely in the top to force more new wood below.

Fig. 10.—Eight year old peach tree that has been well pruned and trained. Notice how well the fruiting wood is distributed throughout the head. See how nearly it conforms to a right angle. An ideal shaped tree and the heavy pruning in the top indicates that the pruner does not intend to let it grow away from him. This tree is good for seven more years at least.

Fig. 11.—A tree of the same age as that shown in Fig. 10. The pruner has tried to increase the bearing surface by increasing the height of the tree, and notice the result. A tall, leggy tree with no fruiting wood below. This tree would be a good subject for a system of pruning similar to that shown in Fig. 12.

Fig. 12.—A peach tree severely cut back for the purpose of forming a new top. Some of these stubs will die back but the tree will form a good, new top. It would have hardly been safe to cut to stubs of this size had it not been for the smaller wood below.

Fig. 13.—A new top, two years old, on an eleven-year-old peach tree. Such a new top is well worth the loss of one crop of fruit.

Fig. 14.—A pear tree improperly headed-in. It is only reasonable to suppose that leaving large stubs with numerous fruit spurs bearing branch buds would result in a large number of sprouts. Heading-in will, of course, always start some sprouts, but their number may be greatly lessened by cutting back the leader to side branches.

Fig. 15.—Is the same tree as that shown in Fig. 14 one year later. It tells the whole story.

both terminal and axillary buds, the terminal with few exceptions being a branch bud and those developed in the axils of the leaves mostly fruit buds. Fruit buds are also found as axillary buds near the base of the stronger growing new wood. The cherry, then, has a fruiting habit which would indicate that the tree will stand only moderate pruning. Trees overpruned produce an excess of strong, new wood with few fruit buds. In neglected trees the spurs become weak and spindling from constant bearing; the flowers are borne singly in the buds, when they should be in pairs or triplets, and the tree produces a large number of medium-sized fruits.

The manner of pruning will depend somewhat on the variety, but the general plan should be to keep the fruiting area of the tree as near the ground as possible; to shade the trunk, to prevent sunscald, and to encourage the growth of fruiting wood throughout the entire top. The sweet and semi-sweet varieties are upright growers and will need some heading in to keep them within bounds. The rapid growth forced by pruning must be checked by careful watering. Unless this precaution is heeded immature growth will result and, young trees especially, may be killed outright during severe winters. Like the Anjou pear, some of the cherries produce an excess of weak fruit buds that fail to set fruit. When this is found to be the case it is a good sign that the tree is not being pruned as severely as it should be. Heavy pruning during the dormant season will often correct the fault. On the contrary, lack of bloom is generally due to excessive pruning or overwatering. Occasionally we find a variety where this fault is characteristic, but it may generally be overcome by proper handling.

PRUNING THE PEACH.

There is probably no fruit tree that gives the careful, observing pruner as much pleasure in pruning as does the peach. Results soon indicate whether the pruning is right or wrong, for no fruit tree will suffer more from neglect, and none respond more promptly to careful treatment. This prompt response, so plainly indicated, lends not a little inspiration toward the proper training and care of the peach orchard, and it is safe to say that, largely on this account, no fruit tree is better pruned than is the peach in our recognized peach sections. The practice is simple, and lack of courage is more often responsible for failure rather than complicated principles. As mentioned before, the peach develops its fruit buds in the axils of the leaves, and the fruit is borne on one-year-old wood; a system of fruit bearing that makes severe pruning a prerequisite to successful peach growing.

In pruning the peach the object of the pruner should be to cut out enough wood to force good, strong growth each year; to re-

move superfluous fruiting wood, and to give the tree the desired shape. The mature peach tree should make an annual growth of at least eighteen inches. With such new growth much of the new wood will have to be removed entirely while that remaining may be cut back to remove a part of the fruit buds it carries. While some object to shortening-in the fruiting wood, contending that it injures the fruit, the years of experience of our most careful growers recommend rather than condemn such a system of thinning. While it does not take the place of hand-thinning entirely, it does save a great deal of tedious hand work. It is hard to say just how much of the new wood is to be removed or how much the remainder should be shortened in. Probably four-fifths is removed entirely, the amount removed from that remaining depending more upon the location of the fruit buds. With the older tree it may be half or even more, while in the case of the young tree it may be necessary to leave the laterals unpruned, on account of the fruit buds being nearer the tips. Figure 6 shows a four-year-old Elberta that has made a very satisfactory growth. Figure 7 shows the same tree well pruned. From now on this tree must be carefully watched to keep it within bounds. As the framework stiffens the tree may be spread a little more, but it should not be allowed to go much higher. It is a common practice to do the heavier pruning earlier in the spring, leaving the clipping back and thinning of the new wood until later, some waiting until all danger of frost is past. The pruner should constantly keep before him an ideal form for the peach tree, the well grown young orchard, at the mercy of a careless pruner, may become ungainly and unproductive at the age of ten years. Effort should be made to keep the fruit as near the ground as possible; most of the fruit on a five-year-old tree should be reached from the ground, and in no peach orchard should the picker need a ladder longer than six feet. (See Fig. 5.) The depth of the fruiting area of the peach tree will seldom exceed six or seven feet, and an attempt to increase this depth only results in a smothering out of the wood below. Figure 8 shows a seven-year-old tree that is really getting too high.. Note the scarcity of fruiting wood in the lower part of the tree. This tree may be forced to develop new wood below if the top is well cut back. Figure 9 shows about how such a type of tree should be pruned. This tree could have still been pruned a little heavier in the top. A better plan is to increase the productiveness of the tree by increasing its spread rather than its height. The ideal peach tree is one in which the top just comes within a right angle or, in other words, the spread should be almost double the height. Figure 10 illustrates the point very well. Notice how the head is well filled with fruiting wood, and compare with Figure 11, a tree of the

same age. With such a system of training the first tree will be productive at the age of fifteen years, while the latter, now ten years old, must be rejuvenated by severe heading-in or be discarded as unprofitable. There is no fault to which the old peach tree more often falls heir than that of the absence of fruiting wood in its lower parts. Such wood below can only be maintained by vigorous pruning in the top. The center should also be well filled with fruiting wood, as space may be unnecessarily wasted by training the top too open; the open center is not a necessity in our arid sections where we enjoy an abundance of sunshine. The fruiting wood in the center of the tree will hardly appear as strong as that nearer the tips, but, nevertheless, some of our best fruit comes from short and apparently weak spurs along the larger limbs. Some have tried summer pruning (thinning out the new wood in the center of the tree), hoping to strengthen the wood remaining, but it has not given satisfactory results; too often it starts new growth that is immature and unfruitful.

It is seldom that we read a paper upon the subject of pruning the peach orchard without we see some reference to the treatment of winter-injured trees. With the exception of young trees grown too late, or orchards in higher altitudes or northern latitudes, such injury it not often experienced in Colorado. It is well for the grower to remember, however ,that the winter-injured peach tree makes the best recovery when it has received a moderately severe pruning. Another subject more worthy of mention is that of the rejuvenation of the old peach orchard. The occasional loss of a peach crop by late frosts offers an excellent opportunity to grow a new top on the old peach tree. Figure 12 shows a peach tree headed-in to secure a new top, while Figure 13 shows a tree eleven years old, two years after such a pruning. The cutting back should be done as soon as possible after the loss of the crop can be ascertained; severe pruning as late as the first of June forces rank new growth that develops very few fruit buds. Rather large limbs may be cut if the bottom of the tree has some smaller growth, but cutting to bare stubs over two or three inches in diameter is hardly advisable.

THE PEAR.

The mature pear tree is not one that requires a great deal of pruning, nor does it allow lack of pruning to interfere seriously with its proper behavior, so far as fruit bearing is concerned. However, when the market demands that the fancy pear be from 2¼ to 3¼ inches in diameter, the owner of the old pear orchard is often reminded that the trees need pruning. In general, the manner of fruit bearing of the pear is practically identical with that of the apple. The spurs are a little shorter and give the tree rather a

more barren appearance; and, although some varieties develop axillary fruit buds quite freely, the majority of the fruit buds are terminal on these short spurs. The different varieties vary somewhat in their fruiting habits, and a study of this character will, to a certain extent, indicate how much pruning each will require.

Apparently the grower accepts the upright-growing habit of the pear as the inevitable, with hardly so much as an effort to train it otherwise. With proper training there is no reason why the pear tree may not be grown with a moderately broad and low head. Pears that grow in the tops of high trees are too often scarred, if not whipped off by wind, before they are mature and, besides, it is too expensive to pick them. The forming of the tree belongs more to the province of pruning the young tree; but a little judicious heading-in practiced on the old tree, taking care to cut to outside buds or branches, will improve on an undesirable form. Too often the tree is allowed to grow at will until it is out of reach, and then, in a fit of desperation, the grower resorts to a system of heading-in shown in Figure 14. This system may be all right for the lawn hedge, but it is not well adapted to the pear, as is shown by Figure 15, the same tree one year later. By the time the pruner gets through with this tree he will have decided that it is poor policy to head-in pear trees. Had the pear tree been properly headed-in from the beginning, the result would have been different. It is only reasonable to suppose that leaving stubs of large limbs which bear numerous fruit spurs will result in rank growth from these spurs, especially during an "off-year" when the spurs carry a large proportion of branch buds. When it becomes necessary to head-in the large pear trees, always cut to side limbs and do not make the mistake of choosing an "off-year" to do this severe pruning; a heavy crop tends to check rampant growth encouraged by rigorous pruning.

While some growers really believe that the pear tree will not stand pruning, we know of no variety to which moderate pruning is detrimental. On the other hand, there are varieties which require severe pruning. In spite of the fact that the Anjou pear is a favorite on the market, many growers will not consider the planting of this variety. Yet a few of its more forbearing admirers have demonstrated that its one bad fault (tardy bearing) may be overcome by proper pruning. The young tree blooms freely and apparently sets very well, but before the fruits reach any size the crop thins itself to almost nothing; even the old tree carries a very small proportion of its bloom to maturity. Heavy pruning during the dormant season will stop this shedding and insure a good crop of fruit. The practice of the most successful growers is to cut the tree back each year and remove some of the new wood that may have been forced by the last pruning. When once the tree begins to bear

good crops, there is less trouble about its shedding. Some other varieties are more tardy about blooming, and heavy pruning during the dormant season would only augment this objectionable character. Such varieties often respond to June pruning; and, if they do not, girdling in June will often prove beneficial. In girdling, a strip of bark one-quarter of an inch in width and extending entirely around the trunk may be removed; but perhaps a safer plan is to remove vertical strips of bark one and one-half inches in width, leaving other strips of about the same width intact. If the wood is uninjured these wounds soon heal and do not permanently injure the tree.

It is difficult to say just how much the pear should be pruned; the grower will have to decide that for himself. The main object of pruning the mature tree should be to thin the fruit and thus improve the quality, as well as to encourage more regular bearing. However, the grower must not feel that pruning will take the place of thinning entirely; to get the best results the two must go together.

The subject of pruning the pear could hardly be considered complete without some reference to the control of pear blight. While it is true that when once the pear tree is inoculated with blight, we must lay aside many of our ideas about pruning and cut to remove the affected parts, it is also true that, in a way, the tree may be trained to reduce to a minimum the loss from attacks of this disease. After the tree begins to bear, heavy pruning which may induce rampant growth should be avoided, if possible, as it is generally conceded that blight is more destructive to trees making rank growth. The majority of inoculations take place through the blossoms, and one of the most serious types of injury is that occasioned by the entrance of blight into larger limbs through short spurs. Through these short spurs the germs gain entrance to the larger limbs and often girdle them before discoloration indicates their presence. It is the nature of the pear tree to develop these short spurs in abundance, and it will be necessary to remove them from the base of the larger limbs. Strong new wood may be allowed to take their places, which may later be developed into fruiting branches. Then should blight enter these blossoms, they are far enough removed from the main limbs that the disease may be detected and intercepted before it reaches them.

PRUNING THE PLUM.

Under this head is grouped a large number of species and varieties of fruit differing widely in their habits of growth and of fruit bearing. Were it not for the fact that common practice seems to discourage the pruning of many varieties to any considerable extent, this would be a difficult subject to handle; no well defined

system of pruning would suit all. In their habits of fruit bearing the majority of the plums resemble the apricot very much. Still many of them, like the cherry, show more of an inclination to bear only branch buds on the thriftier new wood. Like the apricot, the plums, with possibly a few exceptions, develop no true terminal buds. Except on weak spurs, the last axillary bud is generally a branch bud which continues the growth of the branch or spur the following season. The fruit buds are developed in the axils of the leaves on both spurs and the ranker growing new wood, the different varieties showing considerable variation in this respect.

The body of the plum tree is subject to injury from sun-scald, and it goes without saying that the tree should be headed low. The young trees of most varieties will need cutting back, and the tops thinning out, to develop them into desirable shaped trees. Some varieties will require pruning to spread them, and others of a more straggling habit, will need cutting back to inside buds or branches to make them grow more upright. As mentioned before, the bearing plum tree, according to local custom, receives at most only moderate pruning. As a rule, the Domestica plums, locally represented by the various prunes, are pruned very little after they reach the bearing age. There are certain varieties which tend to overbear, however, and a certain amount of thinning out of the fruiting wood would greatly facilitate hand-thinning, promote more regular bearing, and improve the quality of the fruit. The pruning of the native plums is left largely to nature, although there is no reason why moderate pruning might not improve the quality of the fruit and lessen the difficulty of picking. There is little doubt but that such varieties as the Burbank, Abundance, Satsuma, Red June, and others of the Japanese group, respond satsfactorily to rather severe pruning. In fact, they are more like the apricot in their fruiting habit and thrive under the same system of pruning. When neglected they tend to overbear alternate years. They should receive an annual heading-in and thinning out to force strong new growth, which makes very desirable fruiting wood. While pruning as a means of thinning the fruit is not without merit in the case of the plums, it does not seem to give results comparable with those obtained in pruning the peach. The grower of fancy plums must supplement moderate pruning with hand-thinning.

PRUNING THE QUINCE.

While the importance of the quince industry in Colorado might not warrant the insertion of this paragraph, the almost criminal neglect from which the quince tree suffers as regards pruning would move one to writing a book. Among the fruit trees herein considered, the quince has a fruit bearing habit peculiar to itself. With the advance of spring the dormant buds on the one-year-old wood push out leafy shoots from three to four inches in length and these are terminated by a single flower. While both axillary and terminal buds produce these flower-bearing shoots, the stronger flowers come from the axillary buds on the last half of the annual growth; terminal buds more frequently give rise to branches or, at most, weak flower-bearing shoots. Considering its fruiting habit then, the quince should receive about the same pruning as the peach. While with some varieties the plant assumes a tree-form quite readily, others are, at their best, only a bush. A course of severe pruning for the young tree, however, will aid the grower in securing a desirable shaped tree. When the tree has reached a bearing age it should be pruned annually by thinning out the new wood and clipping that remaining back to about two-thirds of its length. With proper pruning, the quince should produce annual growths from twelve to twenty-four inches in length. Too rank a growth is not

desirable on account of the stronger fruit buds being nearer the tips, and in cutting back such rank growth the pruning must not be too severe. The plant should be made to assume as near a tree-form as possible, and then, in addition, it should be pruned with the idea of growing a goodly supply of new wood each season.

THINNING FRUIT.

In fancy fruit-growing, the necessity for thinning will become more and more apparent as the acreage devoted to orchards increases and competition becomes more keen. While the wisdom of thinning peaches is no longer doubted, the growers are not so willing to take up systematic work in thinning apples and pears. But the time is coming when the fruit-grower will be forced to conclude that it no longer pays to grow poor fruit. Even now, the years that the grower makes a profit in shipping choice fruit, are the exception rather than the rule. There are but few localities where choice fruit cannot be grown, and wherever shipped, such fruit must generally compete with the home-grown product. On the other hand, localities where strictly fancy fruit can be grown are limited, and competition in this class is more impartial. The competition is between localities which are probably equally distant from the market, and the one producing the best fruit is the successful competitor.

To a certain extent, pruning is a method of thinning, but it will not take the place of hand-thinning entirely. The production of a fancier grade of fruit is not the only benefit derived from thinning; it encourages more regular bearing; lessen the loss from the breakng of limbs and gives the grower a chance to destroy insect infected fruit and thus check the spread of insects early in the season. The tree that has been properly thinned should produce a good crop of fruit buds each year, and if it has been properly trained and thinned it will never need a prop. While many have observed that apple and pear trees are inclined to bear alternate years, probably few understand the cause. Fruit spurs with terminal fruit buds, as those of the apple and the pear, generally bear only alternate years, and if the spurs are all full of fruit one year, the next must be an "off-year," as we say. Not only do the spurs fail to bear annually, but if the tree is overloaded, spurs that produce bloom, even though they fail to set fruit, may not be sufficiently nourished to produce fruit buds for the following season. If the tree bears only a moderate crop of fruit, spurs that produce bloom but no fruit, often develop fruit buds the same season. Where the tree is bearing a light load, spurs may mature fruit and develop fruit buds the same season. Varieties differ and, while some are regular bearers under almost any treatment, others show a stubborn inclination to bear alternate years. After the old tree has fallen into the habit of bearing alternate years it is no doubt harder to get it back to a regular bearing habit. "Off-years" are not uncommon with some of the fruit trees bearing from axillary fruit buds, but it is not so pronounced as with the apple and pear.

Thinning the Apple.—Fixed rules to be followed in thinning are hard to give. Much depends upon the general thrift of the trees, and, as in pruning, the grower will have to learn much by experience. If we thin to encourage annual bearing, it will be seen that all the fruit must be removed from some of the spurs and, at the same time, the number of fruits remaining must be reduced to such an extent that the tree is not overburdened. Some thin to leave the fruits so far apart, but a rule fixing a certain space between apples will not hold good in all cases. If we were always sure the tree had been properly pruned, we might be able to give a satisfactory rule to be followed, leaving the fruits so many inches apart. A plan the writer has tried and found very satisfactory is to so thin as to have a certain number of boxes of fruit on the tree. Suppose you decide that the trees should produce ten boxes of fancy fruit each. A fairly uniform grade of apples ranging from two and one-half to three inches in diameter will pack about 150 to the box, and by thinning two or three trees and leaving the 1,500 apples, actually counting them or estimating them as closely as possible, one

learns what a tree properly thinned should look like. With these trees as a model it is surprising how close one can come to leaving just the right number. I think it is possible, by careful work, to come within a box of the ideal. But knowing how much the tree should produce is where the experience counts. Not many varieties of apples will require much thinning before they are ten years old, and at this age the average tree should produce about eight boxes of fancy fruit; some will produce more and some less. After the tenth year a gain of a box per year would be a conservative estimate. Of course, the yield will vary under different conditions; and, while this is not a rule that can be implictly followed, it is surely more accurate than thinning to a certain distance. The thinner first removes defective or wormy specimens, and he should be supplied with a bag to carry the wormy ones from the orchard to be destroyed; then those from the tips of the limbs may as well be removed, for they seldom make fancy fruit; and, if possible to do it and leave the required amount, thin to one fruit on the spur. June and early July is the proper season for thinning apples and pears. Experiments have shown that it pays to thin apples. The fruit is improved in both size and color; the trees bear more regularly, and trees that may break under heavy loads are saved. Some say it is expensive to thin; but, if one stops to think, it really costs no more to pick fruit in June than it does in October. A man can thin from ten to fifteen twelve-year-old trees per day, and the actual cost of thinning should not add to exceed two cents per box to the cost of production. It is true that the results the first season are often disappointing, for an unthinned tree may produce sixteen boxes of fruit that will grade 50 per cent. fancy, while the thinned tree of the same age only produces ten boxes that will grade 95 per cent. fancy. It hardly seems profitable. but the next year will tell, and it is safe to say that two years running the thinned tree will produce as much fancy as the unthinned tree will produce of both fancy and choice.

Thinning Pears.—Methods of thinning pears differ little from methods of thinning apples; the principles are the same. As a rule, the pear tree will produce about as many boxes of pears as will the apple tree of the same age produce boxes of apples. The fruit is generally picked on the installment plan, and it is possible to mature a large crop of fancy fruit; and fruit that is small may be left until it reaches the decided size. Pears running from 135 to 150 to the box are considered ideal size, and pears for such a pack must measure from two and one-fourth to two and three-fourths inches in diameter. Pears larger than three inches are really not as desirable for the fancy fruit trade as those of smaller size. The fruit stands like a pear that can be sold at a profit, two for five cents, and there is no profit to be made in selling the larger ones for that price, and they are not large enough to sell for five cents each.

Thinning Peaches.—In growing peaches much of the thinning is done with the pruning shears during the pruning season, but additional hand-thinning is absolutely necessary. A good grade of peaches should run less than 90 to the box, and we may say it seldom pays to ship smaller fruit. A size that will pack less than 80 to the box is desirable. The young peach orchard that has been properly pruned will do well to average a box of fruit to the tree during its fourth season's growth, and the yield should increase at the rate of about two boxes per tree per year. Unless the trees have been exceptionally well pruned and cared for, they will rarely more than hold their own after the eleventh or twelfth year. The one object of thinning, as practiced with the stone fruits, is to produce better fruit. The thinning should be done before the foliage gets too heavy and before the pits begin to harden. By carefully thinning a few trees and estimating the number of fruits left, one can soon form an ideal to work by. The pruning shears may be used as a help in thinning, and fruiting wood not necessarily needed may be removed entirely.

Bulletin 140

February 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Strawberry Growing

in

COLORADO

BY

B. O. LONGYEAR

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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Strawberry Growing In Colorado.

BY

By B. O. Longyear.

One of the earliest horticultural crops to be cultivated in Colorado was the strawberry. It is probable that plants were first brought into this state from DesMoines, Iowa, by Mr. J. B. Wolf in 1863 and planted on river bottom land west of Denver. Altho this plot was destroyed by flood the following spring Mr. L. K. Perrin, of Denver, who had secured some of these plants, sold in 1865 the first Colorado grown strawberries for $3.50 a quart. This early demonstration of strawberry raising in Colorado has been followed in later years by the development of the business in certain parts of the state into an important commercial industry.

This bulletin presents the methods practiced by many of the most successful strawberry growers in localities where the industry is carried on on a commercial scale.

Soils. While the strawberry can be successfully grown on soils of widely varying character it does best on a sandy or fine gravelly loam. Such soils are more easily worked than those of a heavy, clayey nature and they produce earlier crops of better quality than the latter. Heavy soils, with good natural under-drainage, can be made to yield heavy crops especially when lightened with manure thoroughly incorporated with the soil or by plowing under late growth of alfalfa. Where the soil is not well drained naturally, tile drainage may often be used to remove surface water from the land. For altho the strawberry is a plant that requires a plentiful supply of moisture at the roots it is rapidly injured by a wet soggy condition of the soil.

Location. The land selected for strawberry growing should be level enough so that an even watering of the soil may be secured without danger of washing. Where the land is at all uneven, high places must be lowered and depressions filled, otherwise the soil will be too wet in some places while others go dry. If none but sloping land is available the rows may be run in such manner as to avoid a strong fall by following the contour of the slope.

Preparation of Land. The best growers lay much stress on careful preparation of the land. Fall plowing followed by a second plowing in spring is often practiced. This is especially desirable if the soil is inclined to become lumpy. Sandy loams are capable of good preparation if deeply plowed in late winter or early spring, followed by thorough harrowing. A leveler made of plank is employed to reduce lumps and give an even surface.

In case strawberries are to follow alfalfa sod, fall plowing and

harrowing are practiced and at this time the alfalfa roots are removed as the harrow loosens them. A second plowing in spring followed by the harrow and leveler until the soil is free from lumps completes the preparation of the land.

Fertilizers. Well rotted barnyard manure is the fertilizer commonly used for strawberries in this state. This is plowed under at the rate of 10-20 loads per acre. Fresh manure is somewhat objectionable on account of the weed seeds which it is liable to contain and also because it cannot be readily incorporated with the soil. Where composted manure is not available fresh manure is often used at the same rate.

Hen manure is considered the most valuable domestic fertilizer and where available it is usually applied in the fall or early spring as a top dressing to the rows. Being one of the strongest of manures it must be spread thinly to avoid injury to the plants.

Of the commercial fertilizers, bone meal is believed to be the most satisfactory as its effects continue for two or three years. Nitrate of soda is sometimes used during the blooming period with good results. On account of the readily soluable character of this fertilizer, two light applications, about two weeks apart, are better than a single heavy one. This fertilizer may be applied at the rate of 100 to 200 lbs. per acre.

PLANTING

Time. Spring planting is followed in this state almost without exception. Late summer and fall in this climate are usually characterized by hot days and cold nights and such conditions are unfavorable to starting young plants into vigorous growth. In case of small garden plots it is possible however to set plants in late summer and secure a light crop the following spring, especially in cases where plants can be obtained near by and moved with a small mass of soil around the roots. Potted plants can be obtained from the principal seedsmen for fall setting with the assurance of a fair crop the next spring.

The character of the season will usually determine largely the best time to set plants. In most cases this can be done in April which is the favorite month. Some growers say as early as possible so as to secure a strong growth during the first season.

Plants. Plants for a new plat are obtained either from some old bed near at hand or from the nurserymen. In the former case they are usually dug with a spading fork, often on the day before planting. The plants are placed in wet sacks as fast as dug and kept from drying out by an occasional sprinkling with water.

Plants received from the nursery may sometimes be kept for two or three days if the land is not ready for them and if they are received in good condition. They should be stored in a cool moist place, such as a light cellar, and occasionally sprinkled. Some growers prefer to buy plants from Eastern nurseries where they can be obtained earlier in the season than those from the home fields, and in this way get them well established before hot weather comes on.

The plants selected for planting are those having yellow roots, those with black roots being discarded as old or diseased. Careful growers also prefer plants that are nearest the old ones as the strongest plants are usually the first ones that set on the runners while those at the tips are weak.

Setting the Plants. Previous to planting narrow furrows are run with a shovel tooth cultivator, or similar implement, and the plants are set along one edge of the furrow. Two men work together; one opens the soil with a spade, the roots of a plant are placed in the hole behind the spade and spread apart with the fingers of the hand which holds the plant, the spade is then withdrawn and the soil is pressed firmly against the roots with the foot. The plants when set should have the crowns level with the surface of the soil. A stream of water is allowed to follow in the furrow close behind the planters and in this way the soil is settled and the plants watered at the same time. The distance between rows and plants in the row is varied somewhat according to conditions of land and the variety of strawberry planted.

System of Planting. Two systems, the hedge row or hill system and the matted row, are followed. In the former the rows are set 2½---3 feet apart with the plants twelve to fifteen inches apart in the row. All runners are kept off and strong individual plants are formed. This system is but little practiced here as it is adapted only to small areas on account of the greater amount of labor involved. The matted row is practically the universal system practiced in commercial strawberry growing in this state. It is claimed by some that it is the best system adapted to our climate as the fruit is better shaded from the hot sun while ripening. The usual distance between rows is 3 to 4 feet, the more nearly level the land the farther apart. For many varieties the plants are set 12---18 inches apart in the row, while such as the Senator Dunlap and other strong spreading sorts are set 18---24 inches apart.

Cultivation and Irrigation. The first irrigation is given at planting time and thereafter as often as needed to keep the young plants in a vigorous growing condition. Cultivation is given as soon after irrigation as the land will admit without danger of puddling the soil. Irrigation is not usually necessary oftener than every ten days to two weeks and the best growers aim to keep the plat absolutely free from weeds, especially during the first year. This necessitates hand hoeing together with the work of the cultivator. Of the latter implement one having twelve to fourteen spike or narrow shovel teeth and capable of being narrowed down readily is preferred by most growers. As the season advances the cultivator is gradually narrowed thus allowing the runners to root along the sides of the rows. In most cases the matted rows will be fifteen to eighteen inches wide at the end of the season with a correspondingly narrow clear space between them. Cultivation and irrigation are as a rule discontinued by September first to fifteenth depending somewhat on how late weeds continue to appear.

Winter irrigation is impossible in many districts because water is unobtainable at that season. In districts where water is available

however, two or three winter irrigations are considered very desirable and some growers prefer this to winter mulching.

Mulching. Considerable difference of opinion exists regarding the benefits of winter mulching. The majority of growers consider it desirable especially where winter irrigation is not possible. For this purpose straw, manure, marsh hay, or similar material is made use of. Many growers prefer a light mulch of fine rotted manure placed on the row as it does not require removal in spring. In many localities it is difficult to make any mulch stay on the plants on account of strong winter winds. Brush, poles, or similar material, when it can be had, is sometimes used to hold the mulch in place.

Cultivation is resumed the second year by some growers as soon as growth begins, after first removing the mulch, if any has been used, and is continued until the fruit sets. Others prefer to leave the mulch between the rows and pull the weeds by hand as they appear above the beds without giving further cultivation until after fruiting. In most cases, however, the mulch is removed as it would interfere with irrigation and shallow furrows are run between the rows for this purpose.

During the fruiting season irrigation is given frequently enough to keep the plants well supplied with moisture. Drying of the soil at this time not only reduces the size of the fruit but shortens the period of bearing as well. It is found that the rows should not be over eighteen rods long between laterals. Greater length than this necessitates keeping the water too long a time in the upper end of the rows in order that it may reach the farther end. The desirability of having the land as even as possible is apparent at this period for the plants in depressions are then flooded after which the fruit scalds under the hot sunshine. Irrigations during the picking season are given as soon as possible after the pickers have been over the field in order to allow as much time as possible for the soil to dry off before another picking is ready.

PICKING AND PACKING.

The berries intended for the markets are picked when somewhat under-ripe especially when intended for long shipment. The exact degree of ripeness can be gained only by experience and may vary somewhat with different varieties. A short piece of stem left attached to each berry adds greatly to the keeping quality of the fruit. The most successful growers aim to secure good pickers for the entire season. Each picker carries a tray holding six boxes into which the berries are picked directly. When the fruit is to be graded it is desirable to have this done when picking and thus avoid a second handling.

Facing the boxes consists of turning the stems of the upper layer of berries downward in each box. This adds to the attractive appearance of the fruit and is preferred by many dealers. Several methods of tallying the pickers are employed. The simplest is that in which a book or slate is used to record, opposite the name of each picker, the number of boxes picked. Some use tickets stamped or printed with the growers name and numbered 1, 2, 6, 12, 24 qt., each different number being on

cardboard of a different color. These tickets are given to the pickers according to the number of quarts picked and are later redeemed by the grower.

The universal package in use in this state is the Leslie box and crate, each crate holding twenty-four quart boxes. These are usually purchased flat by the grower and made up during the winter or when time permits. Some kind of shelter is necessary under which the packing can be done. This is usually located at one side or end of the field and commonly consists of a rough board shed, a tent or other portable structure.

MARKETING

A great deal of the profits in strawberry growing depends on the market. In several ways a good local market is most desired. The fruit can be handled riper. The grower comes to know his market and a reputation can be established whereby the same customers can be held year by year.

In a large city where a public market is maintained sales may be made often direct to the consumer and peddling by the grower is wholly unnecessary. Even in the smaller towns this may be largely avoided if desired by dealing with the local marketmen.

Many of the best strawberry growing regions, however, are so situated that distant markets must be depended upon. In some cases the careful grower establishes a reputation for first class fruit in one or more distant cities and makes all shipments direct to the dealer. Where this or some other plan is not followed the commission man is usually employed with whom the profits are shared in the form of a percentage .

The establishment of fruit growers associations in nearly all places that have become centers of production has greatly lightened the fruit growing business of the care and responsibility of marketing. This is particularly true where there is no large local demand and where distant markets must be depended upon. In this way the fruit grower can give his whole attention to the business of production and leave the marketing, a business in itself, in the hands of a qualified manager. In the selection of this manager the grower, if a stockholder has a voice.*

The association is able to save the growers a considerable amount by furnishing them with supplies at wholesale and in such quantities as desired. Another important feature of these organizations is the greater uniformity in packages and grading which have thereby been brought about.

These are a few of the features which together with the influence of the fruit growers associations, in bettering the general marketing conditions in favor of the grower, makes this one of the most desirable ways of disposing of the fruit crop.

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*See Bulletin No. 122, Colorado Experiment Station, Fruit Growers Associations.

RENEWAL OF OLD BEDS

Many of the leading growers of the strawberry in the Eastern states recommend taking but a single crop from a plantation. This means getting only one crop from the land during two years. Thus after the picking season is over the plants are plowed under and the land is prepared and planted to some late forage or other crop. This method also requires setting a new plantation each spring and keeping a double area of land in strawberries for at least a part of the time.

In this state, however, two, three and sometimes more crops are taken from a plantation in successive years. Some growers state that the second year's crop is often greater than that of the first year after setting the plants, while the third is apt to be inferior to the first two. The number of crops that can be harvested with profit appears to depend to a considerable extent upon the method of renewal, the care and freedom from weeds, and the use of fertilizing materials. In some cases six and seven crops of berries have been taken from the same plantation before putting the land into other crops but this is not regarded as profitable.

Two methods of renewal, with some varations, were noted. In one method the old rows are narrowed down to about one foot by light plowing or deep cultivating between the rows. During the remainder of the season cultivation and irrigation are given the same as in new plantations, the runners being allowed to root along the sides of the rows until the spaces are only about one foot wide.

Additional thinning of the plants in the rows is frequently secured by "blocking" the old rows. This is done by hand with a hoe or by means of a cultivator run crosswise of the rows.

In the second method of renewal the rows are plowed along one side about one third only of the width of each row being left. The corresponding side of each row is plowed under and the next year the reverse side is thus treated. In this way all of the oldest and weakest plants are removed, and the next year the rows do not stand on the same land as the year before.

This method possesses two distinct advantages over the former. First, it allows of the breaking up and cultivation of the soil in the center of the old row which has become packed and hard. Second, the plants left to send out runners are younger and possess more vitality than those in the center of the old row and are therefore capable of producing better plants. This method seems better adapted to longer duration of the plantation than the former and is the one practiced by many of the most successful growers.

ROTATION

As soon as possible after the last crop of berries has been harvested the plantation is usually plowed under and the land is prepared and planted to some late forage or garden crop. Sweet corn, turnips or late cabbages are most frequently used for this purpose and in long seasons, roasting ears are sometimes obtained from the corn. If the soil is deficient in fertility, manure is often applied to the land before

plowing, in addition to the vegetable matter furnished by the old strawberry plants.

High priced land is usually planted the next year to some garden or truck crop such as tomatoes, cantaloupes, sweet corn, or potatoes. Raspberries are sometimes set on the land the second year to remain as long as they are productive.

Strawberries are often planted again after the third year of growing truck crops. Altho good strawberry land is by most growers considered too valuable for seeding to alfalfa or clover still some of the most successful ones believe it a very desirable thing to do. Where a good stand of red clover can be obtained it is particularly well adapted for this purpose as it is more easily subdued than alfalfa. In case the latter is plowed under it is usually necessary to remove the larger roots from the soil during the process of harrowing.

GROWING A SECOND CROP IN ONE SEASON

During the last few years a number of strawberry growers have succeeded in harvesting a second crop late in the Autumn usually during October. Strawberries at this season bring unusually high prices, some grown near Denver having been sold for $7.50 a crate.

One of the growers in this region follows the plan of mowing the foliage and allowing the patch to dry out as soon as the first crop is off. The old plants in the center of the rows are then plowed out after which the plat is disk harrowed in both directions. This is followed by a thorough soaking of the ground which starts the remaining plants into vigorous growth.

In this way the growth is first checked and then renewed with the result that the plants may blossom and fruit a second time frequently ripening the berries after the first fall of snow.

VARIETIES

Many of the numerous known varieties of the strawberry have been tried in different parts of Colorado. Only a few of these, however, have been found adapted to our conditions and it is often the case that one or two varieties are grown almost exclusively in a certain region. The ideal commercial berry for Colorado is yet to be found and a few growers are continually trying new varieties with the hope of finding one that shall be an improvement over those now grown. The qualities which recommend a variety for home use are not necessarily the same as those which make a desirable commercial variety. A good commercial variety should be hardy, very productive, of good color and firm enough to bear shipping well. It should possess good size and form and should not quickly run small after the first two or three pickings. A variety in which the fruit-bearing stems are strong and erect is found to possess a distinct advantage over one in which the berries are borne close to the ground where they are apt to suffer from sunscald following irrigation.

The mere fact that a variety does well on one farm is no guarantee that it will do equally well in all portions of that region nor even

that it will succeed on the adjoining farm. In most cases a variety which succeeds best in a certain locality may do so largely because of similarity in the soils and the location of the land together with any features which may influence climate.

The following list includes only such varieties as have been found best adapted to the prevailing conditions and practices in our principal strawberry growing regions.

Beder Wood.—(Perfect.) This is the leading variety grown in the Canon City region. Altho one of the earliest, it endures late frosts well. It is very productive, the cropping season is lasting and the size holds up well. The berries, which are medium to large, are borne on strong stems well above the ground. The color is scarlet, the quality excellent. Its principal fault is lack of firmness which unfits it for very long shipments. Probably our best commercial variety as yet for certain sections.

Glen Mary.—(Perfect.) One of the promising market varieties which is being tried in several localities. It is a vigorous growing, medium to late variety with large flattened-conical berries of dull red color and considerable firmness. It is productive but ripens unevenly, with a white tip.

Captain Jack.—(Perfect.) This variety is grown in several localities and is one of the leading sorts in the Denver region. It is a vigorous plant of stocky growth. The fruit is held above the foliage on upright stalks. Berries light crimson, regular form, fair quality and a good shipper. This is a good medium early variety but the berries soon become small after the first pickings. It has not been found as productive as the Beder Wood. Many growers find this variety requires a strong soil and it is recommended for damp, heavy land.

Gandy.—(Perfect.) A large, vigorous plant with few runners, well adapted to hill culture. The berries are large, irregular, bright scarlet, slow to ripen at the tips, quality and firmness good. This variety is quite commonly but not extensively grown as a late variety. It is considered as of moderate value.

Jucunda.—(Perfect.) This is the favorite variety in the Denver and Golden region and together with Captain Jack forms the principal market berry. There it is found productive, medium late and on bottom land the crop holds on well. It is a large variety, crimson color, good quality and firm flesh. This variety was not reported favorably in tests made at the State Experiment Station here several years ago.

Warfield.—(Pistillate.) This one of the older varieties which has been grown successfully in a commercial way in this state. It is vigorous, productive, and the fruit possesses excellent market qualities, being large, firm and highly colored. It must be planted with some perfect flowered variety for which purpose Beder Wood is recommended. It is also highly recommended for home use.

Marshall.—(Perfect.) A large fruited variety which has proven satisfactory to some growers. It requires extra care to get the best results which may be one reason why it is not more generally grown.

Aroma.—(Perfect.) This variety is reported by a few growers as one of the best market sorts on account of its good keeping qualities. It is not found to be quite hardy, however, and has not come into extensive culture.

Senator Dunlap.—(Perfect.) One of the good early varieties in some sections. It is especially prolific in the formation of runners hence this variety should be set farther apart than most varieties.

The berries are medium to small, conical, necked, and deep crimson. The quality is good but the fruit lacks firmness and turns dark on the market. The berries run small in latter part of season largely on account of the numerous runners sent out.

Ridgeway.—(Perfect.) A vigorous, mid-season variety of good productiveness. Fruit large, round-conical, bright crimson, quality good. By some of the prominent growers in the Boulder region this is considered their

best variety, its greatest fault being that the fruit is tender and does not bear shipping well.

Clarke's Seedling. This is one of the varieties which has won a reputation in Oregon from where it is shipped into this state. It is an attractive looking berry of great firmness and keeping qualities. Mr. C. L. Parsons, of Boulder, who has tested this variety reports it as being a poor producer in other localities.
on his place. It is worthy of further tests under different conditions and

Chesapeake.—(Perfect.) Plant vigorous and stocky, berries large, regular, rounded-conical form; color deep crimson, seeds yellow and prominent. This is a new variety producing fruit of excellent quality and firmness and of very attractive appearance. It is being tried by Mr. Joseph Hoyt, of Canon City. It is reported from New Hampshire as being a light producer. In other respects it possesses splendid commercial qualities and is especially promising for home use.

Wm. Belt.—(Perfect.) One of the large fruited vigorous varieties which has done well as a market berry on the heavier, moist soils near Longmont. This variety is also favorably reported from Michigan for its productiveness and vigor.

Splendid.—(Perfect.) This is a vigorous growing variety which forms full matted rows of stocky plants. The berries are large, light scarlet and ripen slowly at the tip. It is reported favorably as a producer for market near Denver.

Cost of Growing, Yields and Profit. The fact that but few of even the best growers keep any records of the expense of growing an acre of strawberries makes it difficult to give any exact statements in this connection. Mr. C. L. Parsons, of Boulder, kept records one year during which the total expense (not including rental or interest on cost of the land) was $105.00 for one acre of strawberries. Mr. J. P. Farmer, of Canon City, estimates that the equivalent of one man's time during summer with horse could care for five acres of berries except harvesting. He also estimates that it will cost $125 to $150 to grow an acre in the best manner, but believes that this is more than is usually put into the crop. In all probability $100 per acre is near the average expense of growing a crop of strawberries as practiced on a commercial scale in Colorado.

The profits in this industry are likewise a matter of great variability as they depend not alone on the cost of producing and harvesting the crop but also on the markets. It costs no more to grow a large yield than a small one. In the former case, to be sure, the cost of harvesting will be increased, and if a large yield is general the price is apt to be correspondingly low. Some general estimates of yields in the Canon City region range from 300 to as high as 800 crates per acre, the latter case being from small tracts. Bederwood in this region produces from 300 to 500 crates per acre in a good season.

From estimates given by growers in other regions and from other varieties it is evident that a crop of 300 crates per acre should be considered a good yield in a normal season.

The cost of harvesting and packing varies less widely than most of the other operations, and is estimated at from 60 to 65 cents per crate in places where pickers are paid 2 cents a quart. An average of the estimates secured on the cost of producing a crate of berries ready for market is about $1.15. The price received by the growers during the

last few years has averaged about $2.00 per crate. Some growers roughly estimate that about one half or 50 per cent. of the gross returns is profit during normal seasons.

INSECTS AND DISEASES

The strawberry is comparatively free from the insect pests and fungous diseases that infest this plant in many other regions. A few growers report the work of the strawberry leaf roller as occurring to a small extent, but not in sufficient amount to make spraying with insecticides necessary. The Experiment Station Entomologist, Prof. C. P. Gillette, states that but very little damage is done by insects upon the strawberry in this state.

Of the fungous diseases of the strawberry the leaf spot is the most common. It seldom occurs however, on vigorous beds in favorable situations to such an extent as to cause appreciable injury. In low, moist situations and on certain varieties it has in some cases been serious enough to call for spraying. Bordeaux mixture is used for this purpose, one application just before blossoming and one or two after harvesting the crop being recommended for this purpose.

A more serious and obscure trouble has been noticed by some growers as affecting the roots of the plants. It has been found most serious on land where the water level in the soil was close to the surface and where the physical condtion of the land is unfavorable for the plants. This trouble manifests itself in the blackening and dying of the roots of young plants before bearing, in some cases appearing at the beginning of the winter season. It also occurs on land that has been continually cropped with strawberries and other garden crops without rotation with some leguminous plant. Some study is now being undertaken here with the idea of determining if possible the cause and prevention of this trouble.

THE NATIVE VEGETATION AND CROPS OF THE COLORADO DELTA IN THE SALTON BASIN.

(Supplement to Bulletin No. 140.)

By Joseph Burtt Davy.

The following general observations were made on a hasty trip into the Colorado Desert between March 25 and April 2 of this year:

The region covers such a vast area that it was impossible to do anything in the way of a detailed study of its vegetation in a few days, as almost the whole time was occupied in travelling from point to point.

The flora is a limited one, very monotonous in character, tracts many miles in extent being covered by an almost uniform vegetation, of but few species and varying slightly in individual composition over large areas, according to the physical or chemical nature of the soil. On this account the native vegetation affords an excellent guide to the general condition of the land.

PHYSICAL CONDITION OF THE SOIL.

Although there is a very marked difference between the vegetation of the sandy mesa and old beach lands and that of the alluvial plain, the *texture* of the soil on the plain itself has practically no effect on the vegetation. The same plants are found alike on the heavy "Imperial Clay" and on the Dune Sand, as well as on all the intermediate soils, with but few and unimportant exceptions. This fact is, however, of minor practical importance in determining the nature of the soil, because the texture of the surface soil is so clearly evident from its appearance to the sight and touch.

The relative humidity of the soil is much more clearly indicated, however. When the water-table is within about twenty feet of the surface, Arrowweed (*Pluchea sericea*) grows luxuriantly, forming dense groves six to ten feet high.

Wherever salt-springs occur, a dense growth of Salt-grass (*Distichlis spicata*) is found, and it is usually accompanied by luxuriant growths of Mesquit (*Prosopis juliflora*), Arrowweed (*Pluchea sericea*), and the Washington palm (*Washingtonia filifera*), although the latter is found nowhere on the plain, (except under cultivation) but only above the old beach line. The Mesquit is evidently dependent, in this region, upon the proximity of the ground-water, or upon periodical flooding. Although it is an exceedingly hardy tree, capable of withstanding adverse conditions inimical to the growth of the few other trees found in the region, it frequently happens that on areas

once covered with a growth of large Mesquit, only dead trees now remain, apparently indicating the lowering of the water-table. The river beds of both the Salton and New rivers are covered with a dense growth of vigorous Mesquit, and the latter also contains large Cottonwoods (*Populus*) and Willows (*Salix*), which gradually disappear at the lower end, or are represented by dead trees, indicating that the ground-water is no longer within reach.

Wild Heliotrope (*Heliotropium curassavicum*, L.), locally and most inappropriately called "Chinese Pusley," makes a rank and luxuriant growth on the banks of canals and ditches where there is a perceptible efflorescence of salts. It does not occur except where the soil is moist.

Salt-grass, Arrowweed, and Mesquit may therefore be taken as good indications of the proximity of the ground-water; Salt-grass indicating surface moisture, Arrowweed indicating water anywhere from the surface to twenty feet, and Mesquit indicating water from twenty feet down to an, at present, unknown depth. It would be of considerable interest, and perhaps of some practical value, to find out exactly how far the Mesquit can penetrate in search of ground-water. This could probably be determined with very close accuracy, as it appears that the lowering of the water-table below an, at present uncertain point, results in the death of the trees over large areas.

CHEMICAL CONDITION OF THE SOIL.

The chemical condition of the soil has a much more marked influence than the physical on the vegetation. This is clearly demonstrated by the distribution of the various "alkali weeds" which occur in equal abundance and luxuriance on all soils in which alkali occurs, from the light "blow-away" dune sands up to the heaviest clays.

THE CREOSOTE LANDS.

The best soils of the region from the culture stand point, *i. e.*, those freest from alkali and of a loamy texture—are characterized by a luxuriant growth of the bush locally called "Greasewood," but better known as Creosote bush (*Larrea tridentata*). The use of the name "Greasewood" should be dropped in connection with this plant, as it is more generally and more correctly used to designate one of the most alkali-indicative plants of Utah, Nevada and Northeastern California (*Sarcobatus vermiculatus*), which is not found in the Salton Basin. The name "Creosote-bush" is thoroughly distinctive and will not lead to the supposition that this shrub indicates the presence of alkali, which is not the case. As a rule, the Creosote bush prefers a light, sandy or gravelly soil, well-drained and almost free from alkali; it is not an alkali plant, and usually grows well

above the alkali line, but at its lower limit a few scattered specimens are often found, in the salt-sage belts, in a mixture of gravel and clay, with some alkali. Mr. Snow found "a few scattering live bushes" growing on soil containing .45 % of salts, or 108,000 lbs. per acre, in 6 ft.; it rarely occurs in such places, however, and then only sparingly and in stunted form. Its presence under such adverse conditions may perhaps be traceable to the seepage or rise of alkali into that spot after the bushes had become established. This theory finds partial confirmation in the occasional occurrence of small alkali spots in the heart of a large area of excellent loamy land, such spots being indicated by the presence of "alkali weeds," particularly Saltwort (*Suæda*), Hop-sage (*Atriplex canescens*) and Scrub Salt-sage (*Atriplex sp.*), associated with the Creosote-bush.

Wherever Creosote-bush occurs abundantly and luxuriantly it is probable that alfalfa and many other crops can be raised satisfactorily. Wherever it occurs mixed with alkali weeds greater care must be exercised in the manipulation of the soil, either on account of lesser permeability of the irrigation water or the presence of larger amounts of alkali.

The entire absence of, or poor growth of, Creosote-bush on lands producing other vegetation, generally speaking (and with a few exceptions doubtless), indicates that the soil is compact, clayey, and hard to work, and usually contains from .6 to over 1% of salts. Such soils will probably require to be leached and possibly to be tile-drained in order to make them respond to cultivation.

It has been suggested that the tracts absolutely free from all vegetation, which are found in some sections on the heavy clay lands, owe their lack of vegetation to the standing of water on the surface for a long period; that they are, in fact, dry lakes, "sinks," or evaporation basins, such as are commonly met with in all desert areas. Without having been able to study the contours of these barren areas, it is impossible to state definitely that this is the case, but the explanation seems a probable one. If this view is correct, then it will follow that the entire absence of all vegetation from an area does not necessarily mean either that the soil is too heavy or that it is too strongly charged with salts for vegetation to flourish, but that the long continued standing of the water has prevented the germination of seeds. Mere seasonal flooding has an entirely opposite effect, moistening the soil for some depth, but drying off the surface in time to allow seeds to germinate.

THE SALT-SAGE LANDS.

The presence of the Salt-sages (shrubby species of *Atriplex*), better known, but erroneously, as "Sage-brush," is invariably indica-

tive of the presence of alkali in varying amounts. The Salt-sages include the Hop-sage or Shad-scale and several other species. Where they grow in company with Creosote-bush there is less alkali than where they grow by themselves, but in almost all cases where they grow alone there appears to be from .4 to over 1.% of alkali salts. In such soils great care will have to be exercised not to allow an accumulation of salts at the surface.

THE SALTWORT LANDS.

The worst lands in the whole region, as regards presence of alkali, are indicated by the growth of three kinds of "alkali weeds," each kind apparently indicating different degree or kind of salt impregnation.

Salt-wort (*Suæda*) is by far the most abundant of these three, and is the principal alkali indicator of the whole region. The amount of alkali required by this plant is considerable, ranging somewhere between .4 and over 1. %, but its exact limits have not yet been determined. It appears to require much more salt than the salt-sages do, and though they often grow in company with each other, it may be considered that where salt-wort or "alkali weed" grows alone, in abundance and luxuriance, there is more alkali than where the salt-sages or "Sage-brush" grows alone.

Rabbit-brush (*Bigelovia veneta*) is not generally distributed—in fact it is a rare plant in the region, and appears to grow only where the salts are excessively strong.

Kern Greasewood (*Allenrolfea occidentalis*) is equally scarce in the vicinity of Imperial. It usually appears to be indicative of excessively strong salts and also of the presence of *black alkali*.

The soils on which the three last-named plants occur contain so much alkali that only alkali-resistant crops should be attempted there. Mr. Rockwood reports that excellent alfalfa is raised on Saltwort lands at Yuma, but it must be borne in mind that the soils at Yuma are generally much more easily leached of their salts than are most of the *Saltwort* lands in the Imperial country. As there is so much land that is practically free from alkali, and that is well adapted to the cultivation of alfalfa, it would be the wisest policy to turn attention to it first, leaving the Saltwort lands to be handled later.

CROPS FOR THE COLORADO DELTA IN THE SALTON BASIN.

In experimenting in a new country and with new conditions, it is wise to try first mainly those things which are most likely to be successful, at the same time neglecting no opportunity to try other things on a smaller scale. On account of the nature of the soil and climate and the situation of the valley, it is probable that the Colorado Delta will have its greatest development in the line of stock-

raising and dairying. Nevertheless, the growing of certain fruits for the early markets of Chicago and the East should not be overlooked, particularly in the line of the production of cantaloupes, watermelons, certain classes of grapes (particularly the Thompson seedless), figs, and dates.

Alfalfa, barley, the sorghums, stock, dairy products, honey, sugar-beets, the fruits above mentioned, and possibly cotton and some of the cereals are likely to be the staple products of the delta. Sugar cane, oats, rice, corn, hemp, flax, and most of the fruits are not likely to succeed. The Sisal hemp plant should be tried; it is more likely to succeed on the mesa lands than on the alluvial plain.

METHOD OF TREATMENT.

Fall-sowing should be practised wherever possible, except in the case of crops susceptible to low temperatures, such as corn and teosinte. Experience has already shown that barley and wheat thrive admirably when sown by the middle of September. Late sowing will, in the case of such crops, be likely to result in stunted growth, and possibly in entire lack of development. By early sowing it will also be possible to secure an early market in many cases.

BARLEY.

When sown by the middle of September, barley near Calexico has made a growth of three and one-half to four feet and headed out by the last of March; it stools out remarkably, producing from seventy to ninety stems from a single root-stock. Attention might be given to some of the fine Bavarian brewing barleys recently introduced by the U. S. Department of Agriculture, for which there may be a good demand in the principal brewing centers, just as there is for Oregon barley, if they can be grown satisfactorily in this region.

ALFALFA.

In preparing the ground for alfalfa it is very important *not* to flood the land after sowing, until the plants have covered the ground well, otherwise a hard crust is formed through which it is almost impossible for the seedlings to break. The land should be well irrigated *before* sowing, preferably twice; then plowed as soon as the surface is sufficiently dry, and harrowed to a fine tilth, in which the seed should be sown and left to take care of itself till well up. There will be enough moisture retained in the soil to provide a good stand in this way, without danger of caking the surface or scalding the seedlings, or causing a condensation of salts. Alfalfa will do best in the lighter, loamy soils. It is hard to start alfalfa in soils of .2 to .4 % of salts; it does best in soils with not more than from 0 to .2 %.

BEETS.

Beets should do well as a winter crop on the lighter, sandy soils. It is not likely that sugar beets can be *profitably* grown on the heavier soils, as the sugar content and purity coefficients are likely to be low.

The Mangold Wurzel (*var. rapa*) is a valuable cattle food, but is not likely to stand the summer heat; it should be tried as a winter crop for summer feeding, as an addition to the alfalfa ration.

AUSTRALIAN SALT-BUSH.

Australian Salt-bush (*Atriplex semibaccata*) can be grown as a forage plant on all lands which are too saline to raise alfalfa and other crops. Some care must be exercised in sowing the seed, in order to produce a good stand, and a bulletin and circular giving a full account of the plant, with instructions as to sowing, can be had on application to the Director, Agricultural Experiment Station, Berkeley, Cal.

THE SORGHUMS.

It is probable that all of the Sorghum races, both saccharine and non-saccharine, will thrive, and will prove important forage crops, as they are in Northeastern Texas. The Sorghums include not only Sorghum, but also Kaffir corn, Jerusalem corn, Egyptian corn, Durra, Millo maize, Broom corn and Guinea corn.

Four crops of Jerusalem corn have been obtained at Indio from a single sowing. This variety is said to be rather more prolific than Egyptian corn, though both thrive well, there and at Calexico.

On account of the scarcity of Sorghum seed in the market and its high price, it might be profitable to raise it for seed as well as for forage.

CORN.

Corn is sensitive to alkali and is not likely to thrive in soils containing more than .2% of salts. It is probable that Teosinte is equally sensitive. Both should be tried as summer crops, as they will not tolerate low winter temperatures.

FIGS.

The Smyrna fig industry has now been placed on what seems to be a thoroughly firm basis, and the quality of the California product is superior to that of the imported article. In view of the fact that in 1900 we imported 8,812,481 pounds of dried figs, valued at $513,895, there would seem to be a market for all the Smyrnas we can produce. The area over which the Smyrna fig can be satisfactorily cultivated is so limited that the likelihood of severe competition is reduced. The successful caprification of the flowers and handling of the crop are not difficult, although they require care and skill, but not more than is

required in the case of many of our special crops, while the prospects for good returns and good markets are much greater than in the case of cotton and sugar cane. Figs thrive at Indio, and should be thoroughly tested at Calexico and Imperial, particularly the Smyrna varieties, together with the necessary capri-figs. Some attention should also be given to the raising of the finest varieties of table figs, with a view to catching an early market. These should be carefully experimented with, however, before attempting to launch out extensively; it is better to make haste slowly in such matters.

A fully illustrated account of the Smyrna fig industry and the process of caprification is contained in the Yearbook of the United States Department of Agriculture for 1900.

DATES.

The Colorado Desert is one of the few places in the United States where the Date palm is likely to grow to perfection. At Indio Mr. G. W. Durbrow now has a number of young date palms, four years old from the seed, which are six feet high. The Date should be raised from suckers of high-grade trees in preference to raising it from seed, as seedlings are apt to deteriorate; care must be taken to secure both male and female trees. A fully illustrated account of the Date industry is contained in the Yearbook of the United States Department of Agriculture for 1900. In this article we find the following note: "The value of the dates imported into the United States, alone, averaged for the ten years ending June 30, 1900, $402,762 per annum, as appraised at the exporting point. The real value when received at the American port was doubtless 50 per cent greater, or $600,000 a year, an amount now exceeded only by the imports of two other dried fruits—Zante currants and Smyrna figs."

TREES FOR TIMBER, SHADE, AND FUEL.

A species of Cottonwood (*Populus*) from the Colorado bottoms and another species from the vicinity of Colton have been used at Indio with success on account of the rapidity of their growth and the good shade they afford. They are objected to on two counts, however: first, the quantity of "cotton" which they shed, and, second, the poor quality of the wood for fuel and other purposes. The first difficulty can be obviated by propagating only from poles or cuttings of *male* trees, which do not produce cotton; the second, only by planting some other kind of tree.

Eucalypts. Some settlers have already invested in seedling Blue Gums (*Eucalyptus globulus*). This species is entirely *unsuited* to the climatic conditions of the region. It will not stand either the low winter temperature or the dry heat of summer.

The true Red Gum (*Eucalyptus rostrata*), the Manna Gum (*Eucalyptus viminalis*), and the Yate (*Eucalyptus cornuta*) are likely to succeed, and are hardwood trees of rapid growth. The Red Gum produces a strong, hard, heavy and extremely durable wood, suitable for fence posts, piles, and railroad ties, and said to make a better fuel than that of the Blue Gum. The wood of the Manna Gum is not as strong as that of many other species, but is frequently employed for shingles, fence rails, and ordinary building purposes. The Yate yields a hard, tough, and elastic wood, suitable for shafts and frames of carts, and considered equal to ash.

The Mesquit is so thoroughly adapted to the climatic and soil conditions of the region that it might be grown in small shelter blocks around the house, as a windbreak and to furnish fuel, and shelter and feed for hogs and cattle. It grows very readily from seed, often coming up as a volunteer on irrigated land and the banks of ditches, and making a growth of from three to four feet in a year with a good supply of water; under favorable conditions it makes a tree fifty feet in height, with a trunk three feet in diameter at the base.

Both the native Washington palm and the true Date palm can be grown for ornament in almost any soil in the region.

In conclusion, the writer would call attention to the fact that in view of the vast area of land, about 1¼ million acres, of which some 160,000 acres has already been taken up, being brought under irrigation, the large number of families already settled upon this land, the peculiarities of the soil and climate of the region, differing entirely from any other region of the State, and largely different from anything else in the United States, that it would be of immense value to the settlers in the region, as well as of great scientific value, to have a State Experiment Station established, preferably in the vicinity of Calexico, and under the direction of this Station, where practical experiments could be carried on, illustrating the best methods of treating the soil and demonstrating what crops can be grown and how they should be handled.

A local station, situated on average land, placed on a permanent basis and with adequate income, would be an object lesson to the farmer of what can be accomplished by the best methods of farming. It would cost at least $3000 to establish and equip such a station, and about $2500 per annum to maintain it.

Berkeley, April, 1902.

Bulletin 141 April, 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

GRAPE GROWING

BY

O. B. WHIPPLE

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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GRAPE GROWING

By O. B. WHIPPLE

Grape growing has not been attempted in any large way by Colorado fruit growers, but it has been proven that the industry is profitable, even when attempted in an amateur way. It is an industry that offers quick returns and it appeals to the man who is waiting for his young orchard to come into bearing, also to the grower who likes to have a variety in fruit growing. Men who have followed grape growing persistently enough to have become practical grape growers are rare. In western Colorado, at least, grape-growing has been carried on in rather a haphazard way by the majority of the growers; or possibly we could express the situation better by saying, in a half-hearted way. The grower has not been altogether to blame; he has been at a loss to know what varieties to plant, how to grow them, or how to market the fruit after it has been grown. In the western part of the state the growers have been planting largely foreign grapes, those of the vinifera class. Many perplexing problems have come up and many growers have become discouraged. In the eastern part of the state the growers have been growing native American varieties and, possibly, with better success.

Vinifera grapes were introduced from California and the grower has naturally tried to adopt California methods of growing them. It has been necessary to modify these methods to suit Colorado conditions. In adapting their methods of pruning to our conditions several bad features have been developed and these, with an abundance of irrigation water, have caused the Colorado grape grower much grief. Yet there is no reason why these difficulties may not be overcome and the return will warrant a more careful study of the methods of growing.

Soils and Locations.—The grape must be planted upon a soil where the moisture conditions may be well controlled during the ripening period if it is to be expected to ripen its fruit properly. To ship well, and to keep well, a grape must be thoroughly ripened, it is hardly possible to get them overripe. A well drained, sandy soil is best, one that will dry out quickly as soon as the irrigation water is withheld. A gravelly hillside is an ideal location as far as the grape is concerned, but sometimes the grower objects when it comes to covering the vines for the winter. Any amount of gravel in the soil makes the covering more difficult. The grape must have plant food just the same as any other plant and it cannot be expected to thrive where other plants will not grow. A southern exposure will probably ripen the fruit a little better than a northern

exposure, yet the latter may be more desirable when looked at from all points of view. The vineyard on the southern slope may bud out earlier and is more subject to injury from late spring frosts. If one is choosing a location to grow grapes exclusively he should choose a locality where late frosts seldom occur and where the season is as long as possible. An early frost in the fall is as bad for many varieties as a late frost in the spring. Unless one can count on almost six months of growing weather it is hardly worth while attempting to grow many of the best varieties of vinifera grapes. Some of the early varieties will mature their fruit in five months of growing weather or even less.

Propagation.—Grapes are generally propagated from hardwood cuttings taken in the fall, stored over winter in moist sand in a cool cellar, and planted out in the spring. The cuttings are taken from well-matured one-year-old wood, each cutting generally containing two eyes or nodes. When such a cutting is set out in the spring the top bud is placed at the surface of the ground with the rest of the cutting buried. New canes laid on the ground and covered with dirt will root readily and form new plants, especially if the cane is barken or partially broken or cut in two at the point where it is covered. While the methods of propagation are simple most growers will prefer to let the nurserymen grow the plants. One-year-old plants may generally be bought for less than five cents.

Preparation of Land and Planting.—The common instruction given for the preparation of the land for the young orchard would apply equally well to the preparation of the proposed vineyard site. The ground should be plowed, preferably in the fall, and put in first-class condition. Ground that is plowed in the spring should be well worked down with the disc and harrow before it is planted.

The vineyard is generally set on the rectangular plan, either 8x8 feet or 8x6 feet. With the low bush method of training commonly practiced with vinifera grapes, setting the plants eight feet apart each way gives none too much room. With the trellis system of training the plants may be crowded to six feet in the row. Still I think it would be better to give them the full eight feet in the latter case.

The vines should be set at about the same depth at which they stood in the nursery, possibly a little deeper. They should be pruned back so as to leave only two or three eyes of the growth of one-year-old wood. The yearling plant properly pruned will consist of the main body (the original cutting) and generally one spur of new wood carrying two or three buds.

Cultivation.—The vineyard should receive good cultivation early in the season, for good cultivation is conducive to good

growth. And since we must check growth later in the season, that the fruit may ripen properly, it is important that we get as large a growth of both vines and fruit as early in the season as possible. The vineyard will profit by an occasional plowing, and if the land is not stirred well during the process of covering and uncovering it should be plowed some time during the fall or early winter. It may be plowed in the spring, but it will be more difficult to irrigate the first time. If the land is plowed from the time the vineyard is set, deep plowing will not injure the vineyard in any way. Early surface cultivation should be made to take the place of irrigation as far as possible. If the vines are not trellised the vineyard may be cultivated both ways to good advantage. One of the A-shaped single-horse cultivators will be found most convenient for vineyard word. After the first of August surface cultivation should be discontinued and the soil allowed to dry out.

Irrigation.—Really the irrigation of the vineyard is one of the most important operations in its management. The injudicious use of irrigation water is responsible for a greater part of the grape grower's grief. The tendency among growers is to use far too much water. The excessive use of water, although it may not be sufficient to actually injure the vines, is largely responsible for the loss from attacks by mildew and, more than anything else, for the poor shipping qualities of Colorado-grown vinifera grapes. One does not realize the importance of having the ground dry during the ripening season of the fruit until he has seen the grapes ripening in the California vineyards. Here the vines are robbed of half their foliage by the drought of late summer and, as a result, the flavor of the fruit is far superior to that of Colorado-grown grapes. The drought prevailing during the ripening season is at least partially responsible for the high sugar content of many California-grown grapes. A grape must carry a high per cent. of sugar to ship well; in other words, it must be well ripened. Still the Colorado grape grower is not altogether to blame, for if he were to allow his vineyard to dry out to the extent that the vines should begin to drop their foliage, his over-solicitous neighbors would go out of their way to advise him that the vines would surely die.

Two points should be observed in the use of water with reference to its relation to the growth of mildew. In the first place, the old system of running irrigation water near the rows and under the vines is a mistake. This plan wets the surface of the ground under the plants where it is slow to dry out and creates a moist atmosphere conducive to the growth of mildew. The grapes also drop down in this furrow and are covered with mud, which induces cracking and decay. A better plan is to run one furrow midway between the rows, make this furrow deep and avoid flooding the

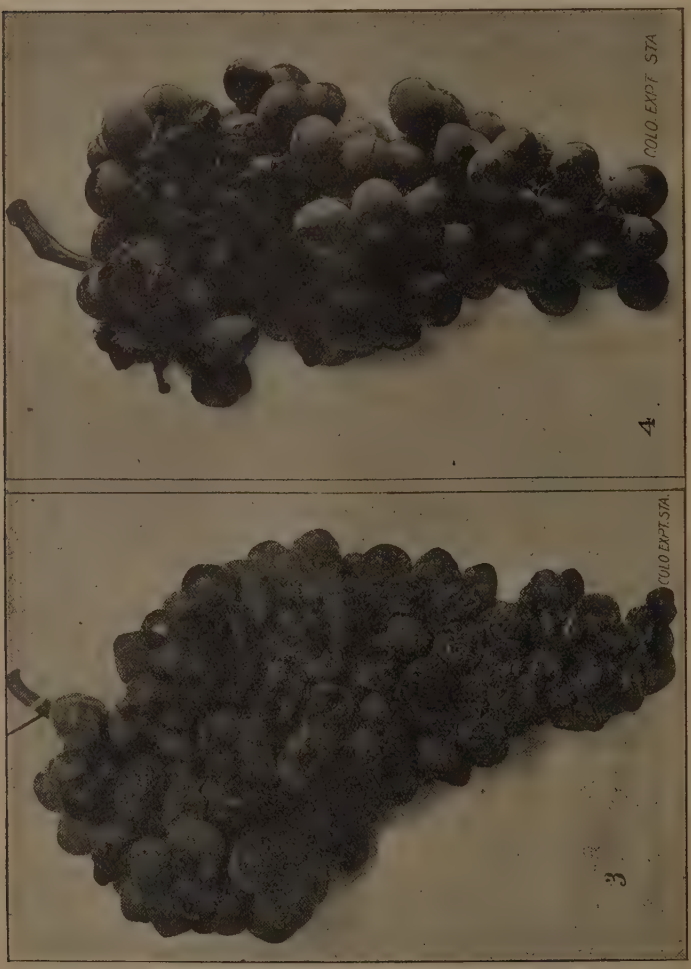

Fig. 3. Shriveling of grapes due to excess of water

Fig. 4. Vinifera grape injured by sunburn

surface of the ground. When the vineyard is watered it should be watered well; then cultivate in the furrows, allow the surface of the ground to dry off, and conserve the moisture by frequent surface cultivation.

The vines should be kept growing well during the early part of the season, but after the berries are well grown, irrigation and cultivation should cease that the ground may dry out. The time for the last irrigation will depend much upon the character of the soil and upon the variety. Even though the foliage may turn yellow and begin to drop before the fruit is fully ripe, there is no cause for alarm; it will not hurt the vineyard and the fruit will ripen better. The cracking of berries is often due to the application of water after the fruit begins to ripen.

The grape will not stand excessive watering and the presence of free water in the soil is early indicated by a dropping of the foliage and a shriveling of the bunches. Fig. 3 is from a photograph of a bunch of Tokay grapes taken from a vineyard suffering from seepage from a ditch. A single heavy watering will often scald the foliage on some varieties. The ground should be kept in the same condition, as regards moisture, as soil for most other crops. The vineyard that has been well dried out during the ripening season will need a late fall watering to facilitate covering and to supply moisture to carry the plants through the dry winters. It is a general impression that the vineyard should not be watered during the blooming season.

Pruning.—The manner in which any plant bears its fruit largely determines the manner in which it shall be pruned. Yet it is surprising how few people are really observing enough to be able to tell you how the grape bears its fruit. The fruiting shoots of the grape spring from axillary buds, buds developed in the axils of the leaves the previous season. Then the one-year-old canes of the grape may be considered the fruiting wood. Axillary shoots from these canes bear from one to four bunches of fruit, the clusters of fruit arising from a joint opposite a leaf. Then, in pruning the grapevine during the dormant season, it should be pruned with the idea of removing as much of the old wood as possible, as well as to prevent over-bearing by removing a part of the new wood produced the previous season. Where the vines must be protected during the winter this is another matter that must be considered in pruning and training the vine. Then, too, it is well to remember that, with most varieties at least, buds near the base of the canes throw poor fruiting shoots and should not be considered.

There are, we may say, two general systems of grape pruning practiced. The one is to leave a large number of short canes and the other a smaller number of longer canes. With either system

the vine is equally well supplied with buds from which the fruiting shoots spring. In most cases the longer system of pruning or training is the more satisfactory. In Colorado it has been the practice to prune the vinifera grapes after the first method. The growers have adopted California methods and modified them to suit our conditions. In most localities it has been considered necessary to protect the vines during the winter, and a system of training similar to that shown in Fig. 1 has been worked out. The vines are trained in a low, bush form, leaving from six to twelve canes carrying four or five buds each. Canes not needed for fruiting wood are removed entirely or cut back to spurs with one or two buds that they may throw strong fruiting canes for the next season.

Fig. 1. Common method of training vinifera grape vines

son. The system has not been fully satisfactory, probably for more than one reason. In the first place, it is impractical to raise the frame-work high enough to keep the fruit off the ground, at least so long as we continue to cover the vines during the winter. Grapes that come in contact with the damp soil color poorly, are liable to crack and mold and are more subject to the attacks of mildew. Then the short system of pruning no doubt materially decreases the yield of many varieties. Were it possible to train the vines with a high stump, as is done in California, or train them on a trellis without protection, the plan might work better. The friut could be kept off the ground, and by spreading the frame-work it would be possible to increase the number of fruiting canes without getting the head too dense. The native grapes are generally trained upon a trellis and given no winter protection. It is the more common

practice, probably, to leave a frame-work of old arms and prune the one-year-old canes back to spurs carrying four or five buds. The number of canes left will have to be governed by the age of the vine and its apparent thrift. To be able to prune the vine intelligently the grower must have observed closely its behavior the previous season. If the new growth is weak and the fruit small it would indicate that the number of spurs left should be reduced. If the new growth is rank and the bunches large and poorly colored it is safe to leave more fruiting wood.

We have mentioned that buds near the base of the canes do not produce as well as those farther out. This is true of most varieties at least. The bunches are generally small and there are not so many of them on the shoot. The following table, taken from Bulletin 77, of the Tennessee Experiment Station, gives the average weight of fruit borne on shoots from the first twelve buds on the one-year-old canes. The first part of the table gives the average yields for single buds and the last part the average yields for groups of three buds:

AVERAGE OF FRUIT PER BUD ON MAIN CANE

BUDS—FROM BASE	1	2	3	4	5	6	7	8	9	10	11	12
	oz.	oz.	oz.	oz	oz.	oz.	oz.	oz.	oz.	oz	oz.	oz.
Concord	2.33	4.41	5.88	6.30	5.90	6.40	5.63	4.37	4.43	4.85	2.90	4.29
Niagara	.44	1.70	4.03	3.04	4.05	5.75	7.34	7.70	4.96	7.40	7.20	4.45
Deleware	.69	1.52	2.48	2.80	2.94	2.32	2.73	3.27	2.56	2.66	2.61	2.56
Brighton	2.15	3.37	4.28	5.23	7.91	7.69	11.14	11.13	8.56	12.04	6.78	6.84

Concord	Average	4.04	Average	6.20	Average	4.81	Average	4.01
Niagara	"	2.06	"	4.28	"	6.67	"	6.35
Deleware	"	1.56	"	2.69	"	2.85	"	2.61
Brighton	"	3.27	"	6.94	"	10.27	"	8.55
For All	"	2.78	"	5.03	"	6.15	"	5.38

It will be seen that up to a certain point the buds more removed from the base of the cane are the heavier producers. This table is compiled from data secured in one season and the author admits that a series of records taken during successive seasons may change it somewhat, yet it is surely worthy of being quoted. While the table gives the results of a test with four varieties of native grapes, it is safe to say that other varieties, native as well as vinifera, would show a similar variation. This, then, is an argument in favor of longer pruning.

It is easy to prune and train native grapes that require no pro-

tection during the winter, with canes eight or ten joints in length. But when we consider that a cane must be trained in a horizontal position to give all buds on the cane an equal chance, it is not so easy to work out a system of long training for grapes that need winter protection. About the only practical system is to start the new canes from as near the ground as possible and train them on a low trellis. In pruning native grapes it is a common practice to leave arms of old wood, train them in an upright position, and train the canes that spring from these arms along a wire. The plan of starting new canes each year from as near the ground as possible also works well if the canes are not trained too upright. Tied up to a stake or a wire trellis in an upright position, the lower buds do not get a fair chance with the rest, and shoots from the spurs left for the production of fruiting-wood fail to develop into strong canes. Fig 2 shows a vine pruned for this system of training; notice the spurs near the ground that are supposed to grow wood for another year. Some such system of training as this would no doubt prove very satisfactory for vinifera grapes in Colorado. If this system is adopted one must be sure and leave these short spurs and train the canes that are to produce the fruit-bearing shoots in as near a horizontal position as possible; in other words, use a low trellis, possibly a single wire. This gives the buds on the spurs plenty of light and all buds an equal chance. It has been demonstrated that the Sultanina and Alexandria will do well when pruned and trained in this manner.

Fig. 2.
Long Pruning of vinifera grape vines

Summer Pruning.—It is a common practice to summer prune vinifera grapes. In the first place one should go over the vines in the early spring and remove all suckers starting from below the ground and watersprouts arising from large arms. These shoots are generally sterile, take the strength of the vine and are poor fruiting canes if left for that purpose. One should go over the

vineyard often rather than allow all the suckers to grow until one general cleaning up. Removing any large amount of foliage weakens the vines.

The fruiting shoots should be pinched back a week or ten days before the blossoming period, the fruit seems to set better. It is a general belief that vines should not be pruned during the blooming season. If the vines are to be pruned with long canes, shoots that are intended for fruiting canes should not be pinched back or cut back. If the bush system of training as illustrated in Fig. 1 is to be followed, the vines are generally pruned back again after the fruit is set, sometimes twice. Summer pruning is weakening, especially if the shoots are allowed to grow long and are then slashed off at some distance from the tip. Such pruning is also liable to expose the fruit to the sun, and a sunburned bunch like that shown in Fig. 4 is the result. In all summer pruning the idea should be to prune by only removing tender growth. It would be safer to make the hired man use his thumb and finger for this pruning. If the grower wants to use a corn-knife, that is his business, but it is a shame to tempt a boy or a hired man by giving him such a tool.

Native grapes are generally suckered, but receive no further summer pruning.

Winter Protection.—In most parts of Colorado, the vinifera grapes need winter protection. In localities where one can rely on the minimum temperature not going below zero, well-matured vines will pass the winter without protection. American grapes are seldom given any protection, and possibly vinifera grapes would stand much more severe temperature if the vines were well matured by withholding water late in the season. The injury is more probably due to excessive drying out of the tissues, rather than to severe freezing; in other words, the immature canes freeze dry.

The vines are protected by giving them a light covering of earth. This covering need not be heavy, just enough to hold the canes down to the ground, if the vines are pruned long, or enough to cover the new wood of those pruned shorter. The vines are covered any time after they shed their leaves and before the ground freezes. They are uncovered in the spring after danger of frost is past. Yet the uncovering must not be delayed too long, lest the buds start and the tender, bleached growths may be broken off in the process of uncovering or killed by the hot sun afterwards. One may as well take the risk of having the shoots killed by frost as to leave them covered after growth starts. If they can be uncovered during a spell of cloudy weather, some of the tender, bleached growths may be saved. In covering large vines the plow is generally used to throw as much dirt to the vines as possible, and the job is finished with the shovel.

Fertilization.—The grape is not a heavy feeder, but on high soils it would no doubt respond to a light dressing of manure. Heavy applications of manure, however, are liable to stimulate the plant to make too rank a growth and then delay the ripening and impair the color of the fruit.

Picking and Packing.—Ripe grapes ship better than green ones, consequently they should not be picked before they are ripe. The fruit gains little, if any, in flavor after it is picked. The fruit should be picked when it is dry and fewer berries will be broken if it is picked during the heat of the day. Grapes should never be picked after a rain until they are thoroughly dry. The fruit should be picked into shallow boxes or trays and stacked in the packing house and allowed to wilt before any attempt is made to cull or pack it. The boxes should be stacked in a way to give the fruit good ventilation and the house should be well ventilated at night to keep it as cool as possible. The fruit should be allowed to wilt for at least one day. If packed too green the stems are loosened from the berries and it is hard to get the required weight in the crate. The bunches will be saved much rough handling if the pickers are provided with convenient shears for clipping the stems.

With the bunches properly wilted so they may be handled without breaking off the berries, they should be carefully gone over and all broken or imperfect berries clipped out with a pair of sharp-pointed shears. One must be careful to see that the inside of the bunch is all right. We sometimes find that compact bunches, apparently all right from outside appearances, are badly moulded near the center. Such a bunch soon spoils a crate of fruit. Small and imperfect berries are mashed easily and are a starting point for moulds. The stem of the bunch is generally clipped quite close to the cluster, but never so close but that it may serve as a handle to lift the bunch by. The bunches should be handled in a way to preserve as much of the bloom as possible.

Foreign grapes are packed in the common four-basket carrier used for apricots and plums. A tin form similar to that shown in Fig. 5 is used and the basket is really packed top first. In putting in the first bunches, which are to form the face of the pack, the bunch is picked up in a way to let the berries droop and then lowered into the form. In this way one builds up the face with no visible stems (Fig 7). The form should be well filled and when the four baskets are in the crate the face should stand high enough to hide the edges of the baskets, giving the crate the appearance of being packed solid. When the form is filled the basket is slipped over it and the whole thing is turned over, as shown in Fig. 6. It will be seen that the real bottom of the form is loose and in removing the form the fruit may be held firmly in place by holding

this bottom down with one hand. The face of the crate should show no stems, should practically hide the edges of the basket, and should stand high enough to give the top of the crate a slight bulge. Cleats on the bottom and top save this bulge from any pressure in stacking the crates. The packed crate should have a gross weight of twenty-eight pounds or more.

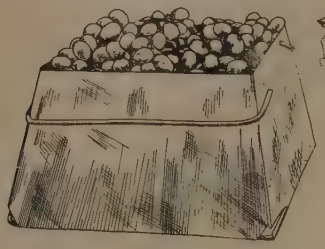

Fig. 5.
Tin form for packing grapes

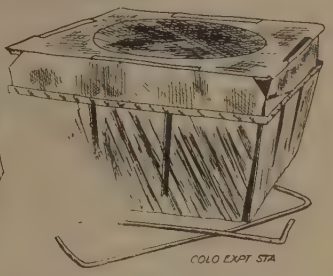

Fig. 5.
Transfer of grapes from form to basket

Native grapes are packed in eight-pound baskets. This basket is commonly called a ten-pound basket, but it holds only eight pounds of fruit. The basket should be well filled and faced as neatly as possible. The fruit should be culled as carefully as vinifera grapes.

VARIETIES.

The number of varieties of either vinifera or American grapes grown in Colorado is not large. Some of the best varieties of the vinifera grape apparently require a longer growing season than most parts of Colorado enjoy. None but the earliest can properly mature their fruit in the higher altitudes. Of these foreign grapes the Flame Tokay, Alexandria (Muscat of), Cornichon, and Sultanina (Thompson Seedless) are easily the favorites. Among the native varieties the Concord, Worden, Niagara, Moore (Early), and Agawam are the leading ones grown for the market.

The following description of leading varieties is not intended so much as an aid to the identification of varieties as to help the aspiring grape-grower to more intelligently choose varieties for planting.

VINIFERA VARIETIES.

Alexandria Muscat of).—Commonly called Muscat. Vine a moderately strong grower on good soil, quite prolific. Canes moderately short jointed; leaves not large, rather round, bright green above; bunches medium size, rather straggling and open, shouldered; berry oblong, greenish yellow to light yellow when well ripened, sometimes slightly bronzed, flesh solid and skin thick, flavor sweet and musky. Fruit ships well, quite attractive. Vine rather subject to attacks of mildew. One of the best grapes and will mature in a comparatively short season. Picked from September first to later in earliest sections of western Colorado, but it is seldom fully ripe before the middle of the month.

Black Hamburg.—This is another very promising variety. Vine strong grower; bunches large, broad at shoulder, rather compact; berries large, slightly oval, skin thick, almost black, firm and sweet. A good shipper and quite attractive, ripens just before Alexandria.

Cornichon.—Vine quite a strong grower, but rather bushy; canes

thick and short jointed; leaves large, dark green, deeply lobed; bunches medium to large, loose; stems long, giving bunch a drooping appearance; berry long, tapering at both ends, dark blue when fully ripened; flesh solid, skin thick; flavor good. Good shipper, and attractive, but can only be matured in localities where one can count on six months from frost to frost, later than Flame Tokay.

Flame Tokay.—Vine a strong grower and a heavy bearer; canes strong, with long internodes or joints; leaves large, dark green, only moderately lobed; bunches large, often weighing five pounds or more, fairly compact, well shouldered; berry large, oblong with rather a flat tip with pistil scar persisting, rather a coppery red, with thin bloom; flesh solid and flavor very good. Fruit a good shipper and attractive. Colors best on rather light soil, fairly free from mildew and a desirable variety where the season is long enough. About thirty days later than Alexandria or (Muscat).

Malaga.—This variety has been little grown in Colorado. It is a white grape maturing only a little later than the Alexandria. A good shipper and one of California's favorite table grapes. California-grown Malagas are found on our markets at Christmas time. May be worthy of more thorough trial in Colorado.

Peru (Rose of).—Black Malvoise, and Zinfandel have been planted. The last two are rather early and soft, split badly in damp weather and mould in shipment. The first is a fair variety, but neither of the three should be considered in a commercial vineyard.

Sultanina (Thompson Seedless).—Vine strong grower and very prolific; canes thick, rather long jointed; bunches long and loose, often a foot long or longer, shouldered; berry small, oval, light yellow, transparent; flesh firm, skin thin, flavor sweet, seedless. Ships well, quite attractive, and would sell well in quantities. Can be easily dried and makes excellent raisins. Variety well adapted to the longer system of pruning.

AMERICAN VARIETIES.

Agawam.—Generally classed as a native grape, although some authorities place it as a hybrid between one of our native grapes and the foreign vinifera. A good red grape slightly earlier than Concord. Has a rich musky flavor and is a good market grape.

Concord.—This is the old standard native grape. It is a black grape of good quality. Vine a good grower and prolific. Ripens about with the Alexandria.

Deleware.—This grape is quite commonly grown. It is a good early variety with a nice flavor. Bunch and berry small. A good bearer, color red.

Moore (Early).—A good early black grape.

Niagara.—A good white grape of good quality. A good bearer and sells very well. A late grape, requiring too long a season to be adapted to higher altitudes. Ripens about with Flame Tokay.

Worden.—A variety a little earlier than the Concord. Berry slightly larger and softer. A black grape of good quality. A good one for home use or for market.

INSECTS AND DISEASES.

Insects.—Very few insects are troublesome to the grape grower in Colorado. Grasshoppers are about the only insect that has been reported as doing any serious damage. They generally migrate into the vineyard from a nearby field where their food has been cut or destroyed in some way, and often in such numbers as to do serious damage before their work can be checked. Early in the season it is possible to kill them by spraying the vines thoroughly with arsenate of lead. This is not always satisfactory, however, as the hoppers work a great deal near the center of the vines where it is difficult to apply spray, and they may do serious damage by girdling canes before they get a fatal dose of poison. Then it is objectionable to spray late in the season with such a poison. A good plan

is to distribute bran-mash on the ground about the vines. This is prepared by mixing forty pounds of bran, one pound of white arsenic, one pint of molasses, and enough water to moisten the whole mixture.

Diseases.—Of the diseases injurious to the vineyard, powdery mildew (U. Spirali) is no doubt the most dangerous. The fungus attacks the leaves, canes, and fruit; but it is on the fruit that it does serious damage. On the leaves it first appears as frosty patches and these later appear as bronzed areas on the upper surface. On the canes it appears very much the same. On the green fruit it appears as a velvety, white coating on the berries and stems. The fruit is checked in its growth, often cracks open, and is ruined for market. On the mature fruit it may only be detected by a slight bronzing of the surface of the white varieties. It softens the skin of the mature fruit and the berries are easily broken in the process of packing, thus giving entrance to other moulds.

This disease may be checked by dusting the vines with dry sulphur or spraying with either the Rex lime-sulphur or home-prepared lime-sulphur washes. To be effective, sulphur must be used during the warm weather. It is best applied with some sort of a blower or bellows, but may be sifted from a cheesecloth bag. In applying it in this crude way care must be taken to not get it too thick, as it will burn the foliage where it collects in the hollows of the leaves. The liquid lime-sulphur sprays are applied with any convenient sprayer. Commercial Rex lime-sulphur is used in strengths

Fig. 7
Full packed basket

Fig. 8
Black knot of grape

varying from one gallon to forty gallons of water to one gallon to sevnty-five gallons of water. The latter strength seems to give as good results as the stronger. Home-prepared lime-sulphur may be prepared by boiling three pounds of good lump-lime and three pounds of sulphur in a small quantity of water for forty-five minutes and diluting the whole to fifty gallons.

Applications for mildew are seldom made before the fungus makes its appearance, but as soon as it does appear it is time for action. It is nice to have faith in ones country to think that cannon breezes will take care of grape mildew, and men have been known to make such a boast, but a light shower and a few warm days afterwards have often proved that such faith is unwarranted. Delays often mean serious loss and it is better to check an attack early rather than wait until the fruit is full grown.

The mould that most commonly attacks the fruit in transit or where it lays on the ground in the vineyard, is the common fruit mould, (Mucor Stolonifer Ehreub).

Crown gall probably destroys a few vines each year, but in many cases frost injury has probably been confused with this trouble. Crown gall is identified by a growth of gall either at the surface of below the surface of the ground. The galls are as much an outgrowth of the wood as of the bark. There is no remedy, and affected vines should be removed. Frost injury is readily distinguished from crown gall in that the wart-like growth

is an outgrowth of the bark alone. The nature of the growth would suggest that the cambium layer has become active during the warm days of early spring and was later injured by severe freezing. The freezing has apparently caused a separation of the wood and bark and the callus is tissue laid down by the bark in an attempt to heal the wound. The nature of the growth is well illustrated in Fig. 8. Canes severely injured seldom start any strong growth from above the injury.

Cost of Growing and Returns.—Few growers are able to give accurate data as to the cost of growing and marketing grapes. The following estimate of the cost of growing vinifera grapes is furnished by one of the most careful and one of the most successful growers in western Colorado. This does not include the expense of picking and packing, at least five cents per crate, and the cost of the crate and baskets, fifteen cents. The vineyard should be in full bearing in its fourth season. This estimate is probably the maximum in both expense and production:

ESTIMATE.

First Year, Expense—	
680 Vines, 8 feet apart, at 2 cents	$13.60
Plowing and leveling	3.00
Planting, 2 days at $2.50 per day	5.00
Cultivating, 4 times at $1.50	6.00
Irrigating, 4 times at $2.00	8.00
Pruning and covering, 2 days at $2.50	5.00
	$40.60
Second Year, Expense—	
Uncovering, 1 day	$ 2.50
Four irrigations, at $2.00 each	8.00
Four cultivations, at $1.50 each	6.00
Pruning and covering, 2 days at $2.50 per day	5.00
	$21.50
Early bearing varieties will produce perhaps 50 crates at $1.00 per crate, $50.00.	
Third Year, Expense—	
Uncovering, 2 days at 2.50 per day	$ 5.00
Four irrigations, at $2.00 each	8.00
Three cultivations, at $1.50 each	4.50
Pruning and covering, 3 days at $2.50	7.50
	$25.00
Will yield about 300 crates at $1.00, $300.	
Fourth Year, Expense—	
Uncovering, 2 days at $2.50 per day	$ 5.00
Four irrigations, at $2.50 each	8.00
Two cultivations, at $1.50 each	3.00
Pruning and covering, 4 days at $2.50	10.00
	$26.00
Will yield about 680 crates at $1.00 per crate, $680.	

Returns from the vineyard will vary according to the care it receives. The vinifera vineyard, in good bearing, should produce about a crate of fruit to the vine, or close to seven hundred crates per acre. The average price received for these grapes is probably seventy-five cents per crate f. o. b. Native grapes should produce close to 2,500 baskets per acre, if the vines are properly cared for. The average price which the grower receives per basket will possibly be close to twenty-five cents.

Bulletin 142 March 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Tillage, Fertilizers and Shade Crops for Orchards.

BY

WENDELL PADDOCK.

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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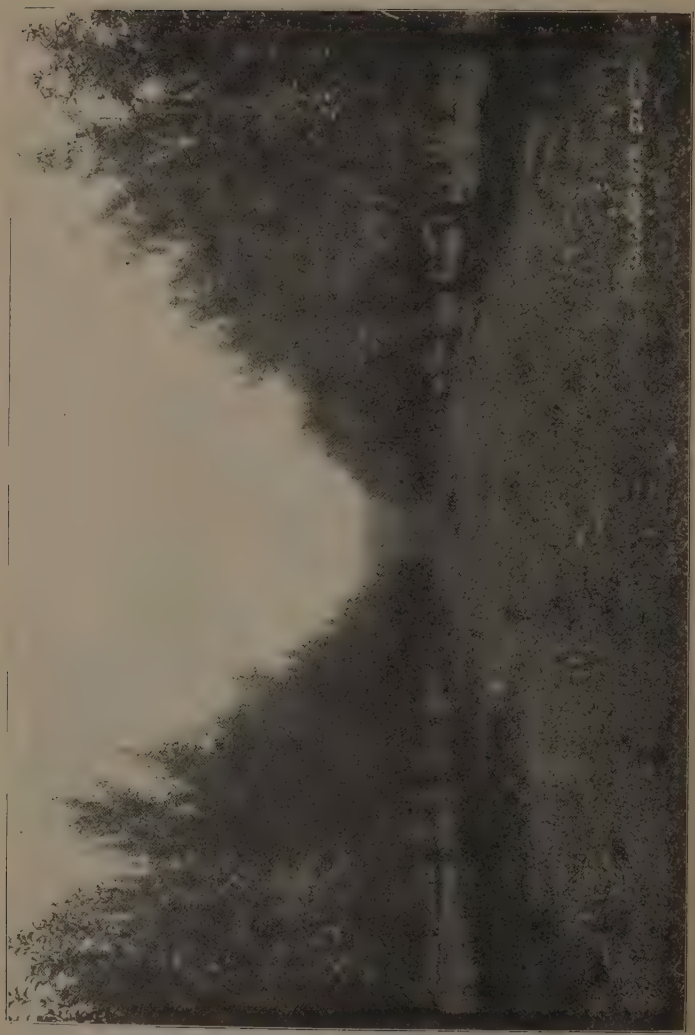

RED CLOVER AS A SHADE CROP

Tillage, Fertilizers and Shade Crops

for Orchards.

WENDELL PADDOCK.

Clean cultivation has been practiced by the majority of our orchardists from the time the first trees were planted. It would be difficult to explain just why this plan has been followed but it is probable that it was brought to us from California. While a certain amount of cultivation is necessary we wish to state emphatically that we do not believe in any system by which the soil is exposed to the action of Colorado sunshine during the heat of the summer. In fact, we believe that this practice has been very much over done and the older orchards are in some cases beginning to show the effects. We may well profit by the experience of fruit growers in other states and in this connection the following quotation should be instructive:

"For a quarter of a century great areas of vineyards yielded thousands of tons of grapes. All these years, under the stimulus of success, these same areas of land received clean, annual and (may we not truthfully add) **merciless** cultivation. The natural fertillity of the soil was gradually reduced by enormous crops of fruit and its physical condition lowered year by year, without the restoration of any considerable amount of plant food or vegetable matter. After the lapse of many years, from various troubles and diseases, the vigor and fruitfulness of the vineyards waned and the industry began to languish. Hundreds of acres of vines were pulled out and the land immediately and without improvement set to peach trees which, for another long term of years, and under the usual relentless culture without the addition of humus in any form, thrived and produced numerous, heavy crops of fruit. Again, as the remaining store of fertility became further depleted by the searching root systems of adult peach trees, enemies began to appear and make their presence felt. San Jose scale and leaf curl fell upon the Island as a scourge and came near writing the final chapter in the history of successful peach culture there. With the destruction of great areas of orchards by the scale and the injury of thousands upon thousands of trees, upon which the scale was not quite successfully combated, it is only natural that great discouragement and depression should overtake the orchardists, so long accustomed to bountiful rewards for labor performed under such favorable conditions."

Has not Prof. Green* truthfully portrayed what we have a right to expect will happen to Colorado fruit growers if our system of orchard management is not changed? No sane man should hope to continue to take large crops of first class fruit from an orchard for very many years without doing something to restore the lost fertility. True we do not expect to have the San Jose scale or the peach leaf curl to contend with, but both are possibilities. We have however been faithful in giving clean cultivation and when one comes to think of it,

*Green, W. J. and Ballou, F. H., Ohio Expt. Sta. Bul. 157, p. 118.

do not the expressions, "merciless cultivation" and "relentless culture" aptly describe this system?

Prof. Bailey** has summarized the benefits of tillage as follows:

1. Tillage improves the physical condition of the land.
   (a) By fining the soil, and thereby presenting greater feeding surface to the roots;
   (b) By increasing the depth of the soil, and thereby giving a greater foraging and roothold area to the plant;
   (c) By warming and drying the soil in spring;
   (d) By reducing the extremes of tempreature and moisture.
2. Tillage may save moisture,
   (e) By increasing the water-holding capacity of the soil;
   (f) By checking evaporation.
3. Tillage may augment chemical activities,
   (g) By aiding in setting free plant-food;
   (h) By promoting nitrification;
   (i) By hastening the decomposition of organic matter;
   (j) By extending these agencies (g, h, i) to greater depths of the soil.

A composite of the practices of a number of the most successful fruit growers results as follows: Use the turning plow in the spring, each year or often enough to prevent the ground from becoming hard. Follow the plow with a harrow or disc, if lumpy, and this with the smoothing harrow. Some use a float instead of the harrow. The subsequent cultivation consists in going over the ground often enough to prevent a crust from forming and to keep the weeds down. This necessitates cultivation after each irrigation and after rains. The Planet Jr. cultivator and the smoothing harrow are used for this purpose. Cultivation is continued until the branches are bent down by the fruit which will average about the first of August.

Winter cultivation is practiced when the condition of the ground will permit. Two cultivations during the winter is considered to be about right. The Planet Jr. or a disc harrow is used for this purpose.

Turning now to the classification of the benefits of tillage it would seem at first thought that the system followed by our best orchardists met all requirements. We find first that tillage improves the physical condition of the land. By the physical condition is meant its tilth and general make up, whether it is compact and heavy or whether it is loose and loamy. But any one who has traveled about among the orchards knows that in the majority of cases the soil is far from being loose and loamy. On the contrary, it soon becomes compact, lacks fibre and it becomes puddled after irrigation or rains. We have even seen orchard soils so hard two inches below the surface that an opening could be made into it only with the aid of a pick. And yet thorough cultivation had been given the land for years. Evidently something is wrong, so we follow on down the classification and find under i, that tillage may hasten the decomposition of organic matter. Here we believe is the cause of our difficulties. Cultivation, bare soils and intense sunshine do hasten decomposition

**Bai'ey, L. H. The Principles of Fruit Growing p. 139.

and in fact the burning up of such material. The classification is correct but we have failed to adapt our system of cultivation to the climatic condition.

We are absolutely dependent upon decaying organic matter to keep the soil in proper physical condition; that is loamy and friable. But upon examination we find that this material is largely absent, having been literally sacrificed as a burnt offering to the gods of clean cultivation.

A certain amount of cultivation is necessary but one need not wear out his soil in an effort to supply it. As will be seen in the following pages, we advocate growing a shade crop in the orchard during hot weather. If this system is adopted, the land should be plowed at least every second season, depending upon the soil. By so doing a sufficient amount of cultivation will be given the land and at the same time organic matter will be supplied.

In the case of young orchards, unless the ground is very poor, some hoed crop will probably be advisable. Such crops shade the soil and their growth need not interfere with the proper development of the trees. Among the crops used are cantaloupes, potatoes, squashes and corn.

We often hear it said that Colorado soils are well nigh *inexhaustable, and indeed it is true that they are fairly rich in many of the elements of fertility. But we now know from experience that land cropped year after year to wheat becomes unprofitable, even the second crop of potatoes is rarely satisfactory and all fruit association men and local dealers know that small apples and pie peaches are becoming more and more common. In several sections of the state the land was planted continuously to wheat in the early day and as any one would now expect the soil became exhausted and in some instances the farmers faced bankruptcy. This same land is now producing immense crops of wheat, oats, sugar beets, potatoes and alfalfa. What has brought about the change? Alfalfa was introduced about the year 1863. It was adapted to our conditions from the first and soon large areas of this land were growing luxuriant crops of this unexcelled forage crop. The feeding of animals was then in its infancy and alfalfa soon became a drug on the market. It was then found that alfalfa sod could be successfully broken and much to the surprise of

*Some of our readers have no doubt seen the papers on various phases of soil fertility published during recent years by the Bureau of Soils of the Department of Agriculture. This bureau is attempting to show that there is no such thing as soil exhaustion as is generally understood, but rather that there is an inexhaustable supply of all of the mineral elements of plant food in all soils at all times. They contend that the decreased yields of the various crops is due to poisonous substances excreted by the roots of plants. Thus, according to this view, any crop will soon poison the land to such an extent that proper development of the plants is hindered and decreased yields result. The remedy according to this theory is, naturally, a proper rotation of crops. The idea that the roots of plants excrete poisonous materials is an old one and one which we believe to be true with some plants at least. But that this is accountable for all of the many cases of unsatisfactory yields is difficult to believe. At any rate the writer prefers for the present to adhere to the well established theories, believing that the available supply of plant food may be depleted and that the texture of the soil counts for much. The presence of decaying vegetable matter in the soil improves its physical condition, helps to set plant food free and in a measure takes the place of crop rotation in the orchard. This may best be supplied and conserved under arid conditions by the use of shade crops.

all, when planted to wheat the yield per acre was far greater than when the land was first subdued.

Now what had the alfalfa done to the soil? It had actually added some nitrogen which by the aid of the nitrogen fixing bacteria it is able to gather from the air. It also brought up from the lower depths of soil, ten or more feet below the surface, potassium and phosphorus. These two important elements of plant food were deposited in the surface soil in the shattered leaves and stems as crop after crop was removed from the soil and when the sod was broken the decaying roots and stubble added their quota. But more important than all these, decaying vegetable matter and its products had been added to the soil. Without decaying vegetable matter the physical condition of the soil is almost ruined for agricultural purposes and the host of bacteria which perform many essential activities are prevented from developing.

Our orchards have, for the most part, been planted on desert land and in most cases the land was cleared of the native growth and planted directly to trees. Thus there was little or no vegetable matter in the soil and, since our growers have been very insistent on clean cultivation and stable manure is scarce, but little has been added. Now does it not stand to reason that continued croping to apples or to peaches will bring the same disastrous results that befell the wheat growers mentioned above? The following table complied by Dr. Roberts* is valuable in this connection. Table I shows the amounts of plant food elements which are removed in the grain and straw in twenty years of continuous cropping to wheat. It is assumed that an average of 15 bushels of grain and 35 pounds of straw are removed from an acre each year.

Table I. Amounts of Plant Food Removed From an Acre in 20 Years Continuous Cropping to Wheat.

	Nitrogen lbs.	Phos. Acid lbs.	Potash lbs.	Value
Grain	424.80	160.20	109.80	$79.86
Straw	234.78	50.40	214.20	48.37

In contrast with this the same author gives similar figures of the amounts of plant food which may be expected to be carried away in 20 years in fruit and leaves from an acre of bearing apple orchard. The figures represent 20 years of the productive life of a New York apple orchard between the ages of 13 and 33 years and does not include the materials stored in the wood of the tree.

Table II. Amounts of Plant Food Removed From an Acre of Apple Orchard in Twenty Years.

	Nitrogen lbs.	Phos. Acid lbs.	Potash lbs.	Value
Apples	498.60	38.25	728.55	$110.26
Leaves	456.75	126.	441.	97.17
Total value in wheat, grain and straw for 20 years				$128.23
Total value in apple, fruit and leaves for 20 years				207.45

These figures show that an apple crop takes more fertility from

*I. P. Roberts, Bull. 103, Cornell Experiment Station.

the land than wheat and most farmers know from experience that continued cropping to most farm crops leads to disaster. The day of reckoning does not come quite so soon, perhaps, with mismanaged orchards but it is none the less certain. The fact that trees grow to great size and live for many years in forests, does not apply to growing apples, unless, perchance, they are grown for cider. The quicker the fruit grower realizes that each crop of fruit makes large inroads upon the available supply of plant food the quicker will he awaken to the fact that scrupulously clean cultivation is not all there is in the handling of orchard soil.

There are 38 elements which enter into the make up of a plant; 10 of this number are essential to its proper growth. These elements are as follows: Carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, calcium, magnesium, and iron. Normal development of a plant is impossible if a single one of these elements is absent. Only three of this number are considered, ordinarily, in the fertilizing of soil; namely, nitrogen, potassium and phosphorus.

Nitrogen is essential to vigorous growth in plants and an oversupply in the soil often promotes a rank growth of twigs and foliage at the expense of fruit production.

Potassium or potash is especially important in fruit growing since it aids in developing color and is the base in combination with fruit acids. It also forms more than 50 per cent. of the ash of fruits and constitutes a large proportion of the ash of the wood of fruit trees. Phosphorous is not so important in fruit growing as in grain production as it enters largely into the composition of seeds. But it is an essential constituent of tree and fruit and aids particularly in the proper ripening of the latter.

These substances are supplied in various forms in commercial fertilizers and it would seem to be a simple matter to supply any one or all of them as the individual orchard seemed to demand. Such manures are used very extensively by orchardists in the eastern states, but so far as we know commercial fertilizers have not been tried in the orchards of Colorado and we hope that their use will not become necessary for many years to come. In any event, freight rates are so high as to make their use almost prohibitive, and then, the benefit to be derived from their use under Colorado conditions is problematical as the following experience would indicate.

Potato growers feel that they should grow two crops in succession after turning under alfalfa sod. The second crop, however, is rarely as good as the first and is very often produced at a loss. To one who is familiar with farming methods as practiced in the East it would seem to be a simple matter to bring up the yield of the second crop by an application of commercial fertilizers. Accordingly a series of acre plots were laid off in a potato field at Greeley to which commercial fertilizers were applied. High grade nitrate of soda, sulphate of potash and phosphoric acid in the form of dissolved bone meal were secured and applied separately and in various combinations. These experiments were carried through four years and at the end of that

time it could not be shown that the fertilizers had in any case produced an increased yield over the unfertilized plots.

How then, are we to maintain the fertility of our orchard lands? We have already seen what the benefits are of plowing under alfalfa to wheat and potatoes, so why not adopt a system of green manuring for the orchard? The Greeley potato growers do not think of growing more than two crops of potatoes after alfalfa has been turned under. If they can afford to grow alfalfa for the purpose of producing better potatoes and in the meantime get but two crops in five years, surely the orchardist can adopt similar methods. There will be no rotation with the orchard crop but an actual saving in labor may be made in that there is little or no cultivation while the green manure is occupying the ground. The potato grower gets some returns, to be sure, from the alfalfa hay and from the grain with which it is seeded but the potato crop is the money maker.

We have already noticed what some of the effects of plowing under green crops are. But the importance of the subject will warrant a repetition. The following summary has been adapted in part from Professor Bailey's writings on cover crops:

I Green manures improve the physical condition of the land:
Shade the surface soil from intense sun in summer thereby protecting the trunk and limbs from the reflection of the sun from the soil; prevent the very rapid burning of organic matter in the soil; conserve some of the surface moisture, and prevent crusts from forming.
Prevent soils from cementing and puddling.
Prevent the rapid drainage of water from loose, porous soils.
Prevent one form of freezing dry.
II. They catch and hold some of the leaching nitrates;
Render plant food materials available;
Appropriate nitrogen if legumious crops are grown.

Cover crops have become very popular in the East in orchard management. The name is derived from the fact that the seed is sown in the fall or late summer and sufficient growth results so that the ground is covered and protected during the winter. The crop is intended primarily for a green manure but under eastern conditions it cannot occupy the land during the growing season. The trees usually need all of the available moisture during that period and clean cultivation is practiced to conserve it. As soon as the trees have made their growth for the season the cover crop is planted and its growth uses up the surplus moisture and thus the trees are aided in maturing before cold weather comes on. Colorado conditions are quite different from the fact that the water is largely under man's control. We believe that our conditions demand a cover for the soil far more in the summer than during the winter. And moreover, nearly as much protection is afforded during the winter if the crop is plowed under late in fall, as is the case when the plants are allowed to stand. We therefore propose the name, *shade crops,* for a system which we hope may come into general use in this state.

Many orchardists have seen young trees killed by running water close to them during a hot day; the reflection of the sun from the

water causing sun scald. It is thought that reflection from a hot, baked soil may cause similar injuries.

As has been noted before, Colorado soils are very deficient in decaying vegetable matter and it is very rapidly dissipated when it is supplied. A summer cover will preform one of its most important functions in preventing, at least a portion of this loss.

Examine a moderately heavy soil in an orchard where a manurial crop is growing. The surface soil under the plants will be found to be cool, moist and friable, while adjacent unprotected land will be found to be hot, dry and compact. This difference is due not alone to the shade afforded by the plants but to the transpiration of immense quantities of water as well. It has been found, for instance that a grass plant will give off its own weight of water every 24 hours in hot, dry summer weather. To be sure it requires more water to irrigate an orchard where any crop other than the trees is grown, but where sufficient water can be had for irrigation this feature need not be considered.

It is a well known fact that our heavier soils, particularly if they are strongly alkaline, become so compact that it is almost impossible to cultivate them after the first irrigation in the spring. It is also true that continued clean cultivation, particularly if plowing is omitted, will make almost any of our soils compact. It is this condition that prevents the proper development of absorbing roots and the setting free of the native fertility of the soil. A few of our fruit growers have shown that green manures in combination with the necessary plowing, will work wonders with such soils as well as with the appearance of the trees growing on them.

Earth worms do damage in some orchards for the reason that they puddle the soil and much of the irrigation water seems to disappear through the channels which they make deep in the ground. A supply of decaying organic matter should do much to overcome these effects.

Soils are occasionally found which are so porous that water leaches down through them much like a seive. If fiber can be incorporated in such land by plowing under green crops this tendency will be overcome, to a certain extent at least.

Many young trees are lost each year in the colder districts as a result of "freezing dry." This term is used as a name for a condition which may be induced in different ways. The usual cause is simply a lack of water in the soil during the winter. Trees give off water during cold weather from twigs and limbs, and if the supply is not replenished, death results. A similar effect is produced when a damp soil is frozen to such a depth that root action is suspended. The tops of such trees usually die after a feeble attempt at putting forth leaves has been made, while the roots are usually in perfect condition.

The condition mentioned first, may be avoided by winter or late fall irrigation. The deep freezing of soil presents more of a problem but we believe that it may be prevented to a considerable extent by the use of shade crops. True, the system we propose contemplates plowing in the fall but eastern experience proves that as much pro-

tection from frost is secured when a crop is plowed into the land in the fall as when it is left standing throughout the winter.

The winter of 1903-4 was very severe in the East and in some sections hundreds of orchard trees, particularly peach trees, were destroyed. Prof Green* made a survey of the injured orchards the following summer and found that injury occured only on impoverished and bare soils. A cover crop, sod, good growth of weeds, or stable manure afforded almost complete protection from the cold. And moreover, and what is more important for our purpose he found that where such materials had been plowed under recently, the protection was just as efficient.

Popular writers on horticultural topics have woefully confused humus with decaying organic matter and have implied that all organic material is humus as soon as it is mixed with the soil and decay has set in. The fact is, humus is the final product of organic decay and as such has entirely different effects on soils than have organic materials which are undergoing the processes of decomposition.

When green manure is plowed into the soil various low forms of plant life including fungi, yeasts and bacteria attack it thus inducing decay. [1]Fraenkel "found in the cultivated soil of Liebefeld 5,750,000, in meadow land 9,400,000, in a manure pile 44,500,000 bacteria per cubic centimeter." These figures seem high for so small a quantity of material, but taking the average size of a bacterium, a cubic centimeter might readily contain six hundred millions.

Other forms of bacteria begin to multiply as soon as fermentation sets in. Different organisms have different and important functions to preform in promoting chemical activities in the soil; plant food elements are set free, changed and combined into substances which plants can use. No less than five different acids are generated by the processes of decay, carbonic acid being among the more important. [2]Sackett found that clover taken in full bloom in June when ground and mixed with soil at the rate of 10 tons per acre, gave off, at the end of three days, [3]carbon dioxide corresponding to 3812 pounds per acre foot. This action continued through a period of three weeks, gradually diminishing however until at the end of that period very little of the gas was evolved. One hundred tons per acre of red clover treated in the same manner gave off after 12 days five tons of carbon dioxide per acre foot. This investigator also tested the solvent action of pure carbon dioxide on various materials. Pure ground bone meal was placed in a flask and carbon dioxide was allowed to pass through it. At the end of one hour 2.11% of the insoluble phosphoric acid had been made soluble. At the end of two hours 5.21% was made soluble. Ground phosphate rock treated in the same manner gave the following

*Green Bull. 157 Ohio Agri. Exp. Sta. 1904.

[1] Hilgard, Soils, p 143.

[2] Sackett, W. G., unpublished notes.

[3] Carbon dioxide and carbonic acid gas are synonymous; when combined with water, carbonic acid is formed.

results: after one hour .16% of the insoluble phosphoric acid had been made soluble; in two hours .28%. Magnesium phosphate similarly treated yielded 16.33% in one hour and 22.35% in two hours of soluble phosphoric acid.

Carbonic acid is, then, an important agent in dissolving rock particles and with its aid, latent fertility is brought into a condition which plants may use.

Organic matter is often almost entirely consumed under arid conditions very quickly after it is incorporated with the soil. The heat of the sun in conjunction with insufficient moisture, produces conditions which oxidize the matter, or in other words, burn it much as though it had been consumed by fire, hence the burning out of soil, an expression common among farmers. This change in organic matter is no doubt begun by soil organisms while the later stages are probably of a chemical nature.

The decay which results in humus, takes place at moderate temperatures. Organisms do not develop in a low temperature and if it is too high, oxidation or burning results. An apparent contradiction to this statement is found in the difficulty with which unrotted stable manure decays when plowed into land, if moisture is not abundant. The lack of moisture probably prevents the development of bacteria in sufficient numbers to begin decay, consequently the chemical changes which result in burning do not occur. The presence of such material is a detriment to growing plants as it keeps the soil so open that an undue amount of moisture is permitted to escape. This effect is so noticeable that many of the so-called dry farmers make no use of stable manure. This wanton waste might easily be prevented by composting as there is sufficient moisture in the rain and snow to thoroughly rot manure treated in this manner.

The compound resulting after organic decay is completed is humus. Such decay results in a dark colored material, without organic structure, soluble in alkalies after the lime has been removed. Humus gives a dark rich color to otherwise light colored soils. It is complex in composition and is especially important as being a reservoir of nitrogen. Much of the nitrogen that is brought to the soil by leguminous plants, as well as that which is stored in the plant in the process of growth, is not made available to growing plants until the humus stage is reached.

Humus usually exists in small quantities in arid soils but often is entirely absent where clean cultivation without manuring has been practiced. It may also be present in small quantities along with partially decayed organic matter. Much of this valuable material is lost by constant clean cultivation and the consequent burning of the organic materials, before it reaches the stage where humifaction may take place.

A large part of the loss could be prevented, not only of nitrogen but of the many benefits to be derived from decaying organic matter and humus as well, by shading the soil.

While it is no doubt true that humus does aid in improving the physical condition of the soil, it is probable that most of the beneficial effect, such as giving fibre, and tilth as well as increasing the water holding capacity, is due in a much larger degree to the partially decayed organic matter.

By leguminous plants is meant the family which includes the beans, peas, clovers, alfalfa and vetches. These are the only plants of importance so far as now known which have the power of taking nitrogen from the air and converting it into combinations which other plants can use. Thus they actually add plant food to the soil and nitrogen is the most expensive element to supply in commercial form as well as the most difficult to keep, since it is readilly dissipated in gaseous form. The manner in which such plants take nitrogen from the air was a mystery for a long time. It was finally determined that a certain species of bacterium lives on the roots of vigorous legumes where the swollen regions or tubercles are formed. This low form of plant life is able to take the free nitrogen from the air and change it into forms which plants can use. Consequently legumes can be grown on land from which nitrogen has been exhausted.

It was also found that leguminous plants do not thrive in soil where the accompanying bacteria are absent. This led to the making of pure cultures of the bacteria which are now supplied in commercial form. These cultures after being diluted and sufficient multiplication of bacteria has taken place, are sprinkled over the land, or better still, seeds are soaked in the culture material just before planting.

Such cultures have not been the success that was anticipated but in the meantime a mass of overdrawn articles on the subject has been printed in magazines and papers. The result has been that many farmers have been lead to believe that by simply applying the cultures to their land wonderful benefit would result to any and all crops. The truth is, these cultures have no direct effect on any plants other than the legumes. And moreover, should one wish to secure such material he must designate the particular crop he intends to grow. Cultures from clover bacteria would not be expected to have any effect on beans or alfalfa. It would be idle to apply these cultures to land which is already producing good crops of any of these plants.

What crops shall be grown for shade crops and how shall they be handled? This is a difficult question to answer as the practice is new and but little has been learned as yet about the subject. The system of cover crops as advocated in the East will not apply for various reasons. We can not plant in the fall and expect to get much growth to plow under in the spring because of the short seasons. Then it might not be advisable to irrigate at the particular time the seed should be sown as would probably need to be done to insure the germination of the seed. We have also found that fall plowing is better suited to our conditions than spring, particularly if a crop or manure is to be turned under. If a mass of vegetable matter is plowed under in the spring the ground is apt to remain so porous that difficulty

is experienced in irrigating. The ground at the upper end of the row soon becomes saturated but still a large head of water must be used in order to force it through to the lower end. Naturally the trees at the upper end are injured. Finally, we believe that both land and trees will be benefited by keeping the surface of the soil shaded during the heat of the summer for the reasons already advanced.

In the light of our present knowledge it will probably be the best plan to prepare the land fairly early in the spring and sow the seed. Or if experience shows that we need a certain amount of spring cultivation in order to aerate the soil and to promote soil activities the planting may be delayed until June. Whether in the case of a perennial it will be best to let it occupy the land for two seasons, plowing it under the second fall, or not must be determined by experience and individual conditions. It now seems best to plow the land at least every second season. All of the land may be occupied by the crop in old orchards but with younger trees space must be left for irrigation as well as to prevent the possibility of the crop appropriating food and moisture to the detriment of the trees. There would also be more danger of injury from small vermin and grasshoppers; the latter pest would probably have to be reckoned with in the young orchard at any event.

One must take pains to see that the irrigating furrows are kept open and not allow them to become choked with vegetation. Provision must be made so that water may be as judiciously distributed as though the land were bare. The trees should always receive first consideration; do not allow the prospects of a few jags of hay to warp judgment when it comes to a question of the health of the trees.

Whether or not it will be advisable to remove any of the crop for hay must be determined for each orchard. When the land has been badly impoverished, or is in poor physical condition, all of the growth should be returned to the soil.

If, later on it is found that the continued use of legumes is furnishing too much nitrogen, as will be indicated by a rank growth, then a change should be made; rye or buckwheat may be used instead.

The kind of crop which will be best adapted for use as a shade crop is yet to be determined and it is likely that different soils and different localities will demand different things. Red clover is at present most in favor among the few who have tried any crop at all. A number of orchards at Paonia have recently been planted to clover and the results are very satisfactory. It has made a splendid growth, even close to the trunks of the largest trees. (See Plate I.) Clover also does fairly well in the northern district. Winter vetch has been tried to some extent, for several years in the vicinity of Rocky Ford. This plant will make a fairly good growth in any of the orchard districts of the state. A few orchardists are experimenting with Canada field peas. Peas have the advantage that they make a splendid feed if one wishes to combine hog feeding with orcharding. The pods will not fill nearly so well, however as they do in the higher altitudes where the climate is much cooler. Pea seed should, therefore be planted as early in the season as possible. Cow peas have been tried

to a limited extent but the season seems to be rather short for ther and the young plants are easily injured by over watering. In on orchard where we were experimenting with this crop the plants mad almost no growth, possibly because the proper bacteria were no present. Alfalfa has been tried by some, but at the mere mention o the word most orchardists will hold up their hands in horror. If i were not so difficult to plow it would certainly be an ideal crop fo the purpose. We do not wish to give the impression that we advocat the use of alfalfa but is it not possible that a method of handling ma be devised that will make its use possible, except in stony land? Wh not plant it in rows? then cultivation could be carried on throughou the season if desired. Then if the tops are mown off before the see has set there ought not to be a great deal of trouble with its spreading If the turning plow is used when the plants are not over two years ol it is not such a difficult matter to cut the roots and the ground wil usually need to be plowed that often at least. But if one wishes t continue to grow alfalfa in the orchard it would be an advantage no to kill it out but to have it contiue to come up year after year. Mr B. A. Smith, of Grand Junction, has been experimenting with alfalfa i one of the best orchards in the Grand Valley and he is very muc pleased with the results so far. He does not plan to kill the plant but expects to use the plow and the disc as much as the land seem to require.

Bulletin 143 March, 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

CABBAGE GROWING

BY

E. R. BENNETT

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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CABBAGE GROWING ON THE IRRIGATED LANDS OF COLORADO

By E. R. BENNETT

As the irrigated tracts of land in Colorado have become more thickly settled the price of land has risen. With this the character of the crops grown has changed from the extensive to the intensive. That is, where a few years ago farmers depended on wheat, oats, and hay as their money-making corps they have found that at the present valuation of land in many places these crops do not pay a satisfactory interest. This condition has forced the extensive crops to a great extent to give place to such crops as sugar beets, potatoes, cabbage, and onions.

The culture of these crops under irrigated conditions is a somewhat different problem from that of the unirrigated country, so that new comers may save considerable trouble and expense by following the system which has been worked out and found to give the best satisfaction here.

HISTORY OF THE INDUSTRY.

Cabbages have been grown for home consumption since the early settlement of the country. About 1880 the potato buyers of the Greeley district found there was a considerable demand for cabbage in the southern markets and that they could be shipped satisfactorily in the same cars with potatoes. From that time the industry has gradually grown till the output is now from five hundred to one thousand cars per year. Greeley is near the center of the industry, though more or less acreage is devoted to the crop throughout the northern Colorado districts. So far comparatively few have been grown in the mountain districts of the State, because of the lack of transportation facilities in the high mountain valleys.

SOIL.

The soil best adapted to the growth of the cabbage is a cool, moist loam. An abundant supply of available nitrogen tends to promote leaf growth at the expense of fruit or seed. As the edible portion of cabbage, lettuce, etc., is the leaf rather than the seed, an excess of this element in the soil is beneficial. For this reason the bottom land or peaty lands are generally considered best for cabbage. Nearly any of the soils of this State, however, will grow cabbage successfully if sufficient decaying vegetable matter and manure are added to put them in good condition and to provide the necessary fertility.

CLIMATE.

None of the horticultural products have a wider range as to climate than the cabbage. This vegetable is grown more or less successfully from the semi-tropics to the arctic circle in Alaska. When grown in the South it must be planted so as to mature before the extreme heat of summer. This is also true to a less degree in the northern states and in Colorado, except in the higher altitudes of the mountain valleys. The most favorable climate is found in this State at the altitudes between six and nine thousand feet where the nights are always cool and the days not extremely warm.

PREPARATION OF THE LAND.

Much of the land used for cabbage growing is considered too valuable to rotate in the usual way. If alfalfa sod is used the land may be sufficiently fertile to produce a crop without the addition of manure. In most cases, however, cabbage follow cabbage on the same soil for several years. One successful grower at Greeley has produced a crop of cabbages on the same land fourteen years in succession. In cases of this kind manure is added to the soil at the rate of twenty tons per acre every two years, or ten tons per acre each year.

After the crop is taken off in the fall, the plow is run under each row, turning the old stumps and leaves of the cabbage under. This leaves the surface rough, so as to catch the snows of winter, and exposes more of the soil to the action of the frost. If manure is to be applied it is generally spread on this land during the winter. In the spring before the soil becomes too hard and dry the harrow is run over the tract lengthwise of the furrows, which smooths the surface down to its original level. Following this the ground is plowed to a depth of from eight to twelve inches.

SEEDING.

Seed must be sown from six to seven weeks before it is desired to set the plants in the field. The time of setting early plants necessarily varies

somewhat with the season. For early cabbage the first seed are sown from March 1st to 15th. At least two sowings should be made to avoid danger of accidents and a possibility of the first plants becoming too large before the weather will permit setting.

Seed for early cabbage are sown either in flats in a forcing house or in hotbeds. If sown in flats, the seedlings soon begin to crowd and are pricked out of the seed flats as soon as the first leaf appears. In this operation the plants may be put into other flats one inch apart each way, or they may be put into hotbeds or coldframes. If the seed are sown in hotbeds the seedlings are not generally transplanted at all till time to set in the field. In this case the seed must be sown more sparingly or the young seedlings must be thinned so as not to crowd. Young plants either in the forcing house or hotbed are apt to be tender and are very susceptible to a disease known as the "damping-off fungus." This trouble is the result of a too high temperature, not enough fresh air, or too much water. The disease is hard to control after it once gets a foot-hold, but may be checked to some extent by remedying these conditions and sprinkling dry sand among the plants. When plants are grown in the forcing house or hotbed, great care must be exercised to properly harden them off before setting in the open ground. In the forcing house this is done by keeping the temperature low and giving all the ventilation possible when the weather will permit. If the hotbed is used, the sash may be first partly removed and later taken off during pleasant weather. Properly hardened plants will endure temperatures of from ten to twenty degrees below freezing point after setting in the field. If not properly hardened off, exposure to freezing temperatures often prove fatal.

For late planting the seed is usually sown in the open ground. If large fields are to be planted, two, three, or even four sowings are made. The first seeding is made about the tenth of April with the others following at intervals of about seven days.

The seed in the open ground is sown in a double row system. That is, two rows are sown from ten to sixteen inches apart with space enough between to run a cultivator and a ditch for irrigation. Since the cucumber flea beetle has caused so much damage to the young plants, some growers are growing the plants for late setting in coldframes. In this case the seed are sown is rows in the frames six inches apart and are allowed to grow in this way until setting in the field. These frames are found to be most convenient if made twelve feet long by six feet wide, or in a multiple of those proportions. The frames are made of boards or planks twelve or fourteen inches high on the back or north side, and lower in front. The covers used for this purpose are made of cheap unbleached muslin stretched on three by six-foot frames. By keeping these covers on the beds during the time the plants are pricking through the ground, the beetles are prevented from getting to the plants. A coldframe of the size mentioned will produce enough plants for about one acre of land.

In planning for the crop it is estimated that one pound of seed will produce plants for four or five acres of land, or fifty thousand plants. This, of course, varies with the germinating power of the seed and weather conditions during seeding time.

PLANTING.

The operation of setting the plants differs more from setting in the humid districts than does other operations connected with the industry. In the East, plants may be set even in fairly dry soil without watering, and few, if any, of these plants sustain permanent injury. The intense sunshine and rapid evaporation of moisture in Colorado are such as to make this method impracticable here.

Setting the plants for the late crop is done sometime during the month of June. After the land has been put in a good state of tilth by the use of the harrow, ditches are made with a shovel plow. These ditches or rows are made in the direction which will make irrigation the most advantageous. The distance between ditches differs somewhat with the variety of cabbage to be grown, and varies from twenty-four to thirty-six inches. The majority of growers plant late cabbage in rows twenty-eight inches apart. These ditches are eighteen to twenty inches wide at top and from six to nine inches deep. After the ditches are made, one man goes along the row dropping plants. These are placed from fifteen to eighteen inches apart in the ditch. Another man follows the dropper to set the plants. In this operation the finger or a sharpened stick is used to make a hole in the side of the ditch about half way from the top to the bottom. The plant is placed in this hole, then the soil pushed back around the roots. Water is

allowed to run in a small stream as closely as possible behind the man who is setting the plants. Working in this way, two persons can set from eight to fifteen thousand plants per day.

From four to eight days after the plants have been set, the water is run through the rows, and sometimes this is repeated two or three times before the ditches are filled. When the plants have become sufficiently established the land is leveled. This is done sometimes by hand with a garden rake, but can be done as well and at less cost with a horse and garden cultivator of the Planet Junior twelve-tooth or Iron Age type. Several

1. Cold Frames
2. Filling in Furrows after Plants have become established
3. Harvesting
4. A Cabbage Field

shallow cultivations are given during the season, and it is usually necessary to go over the field once or twice with the hoe to cut the weeds from the rows.

After the first ditches are filled and irrigation becomes necessary, the shovel plow is run between the rows, making a ditch sufficiently deep to run water across the field without flooding the plants.

IRRIGATION.

Few crops are more particular about water than the cabbage. Although it is a gross feeder, it will soon wilt and stop growing if the soil is dry, and on the other hand, if the land becomes water-logged the plants will turn yellow and stop growth. The frequency and number of irrigations then depends on the character of the soil and the amount of rainfall. If

soils are light and gravelly, with good under drainage, the irrigations must be frequent, and there is little danger of over-watering.

HARVESTING.

The harvesting of cabbage is a very simple operation, as the markets reached are not exacting.

The wagon is driven into the field, the heads cut with a knife, so as to leave just enough of the green leaves to cover the white tissue of the head, then thrown onto the wagon. Not all the heads will be ready for market at the same time, so the fields have to be gone over two or three times before all the crop is taken off.

If the crop is to be shipped, the cabbages are hauled direct to the cars. After being weighed the cabbages are either crated, sacked, or sometimes loaded onto the cars loose.

INSECT PESTS AND DISEASES

Comparatively few insects and diseases have so far troubled the cabbage in this State.

FLEA BEETLE.

One of the most serious insect pests up to the present time is the little black flea beetle (Epitrix cucumeris). These insects feed on the stems and cotyledons of the plants just as the seedlings break through the ground. If the insects are plentiful they sometimes destroy all the plants. Growers frequently fail to locate the trouble because of the small size of the insects and their habit of jumping away from the plants when disturbed. This pest is particularly troublesome if the soil forms a crust so that the insects can find protection under the crust as the seedling comes up.

Several remedies, such as ashes, ground tobacco stems, lime and insect powder have been used with varying degrees of success. If the insects are numerous, the only method of preventing the trouble is to grow the plants in coldframes where the insects can be shut out till the plants are large and tough enough to resist the attacks.

CABBAGE APHIS.

This aphis, commonly called the cabbage louse, occasionally causes serious loss. The attacks usually occur after the plants are partly grown. The lice suck the juices from the leaves and cause the leaves to curl. After this curling occurs it is difficult to get at the insects to kill them. The multiplication of these insects is so rapid that the infestation soon spreads and becomes a serious menace to the crop if not checked.

REMEDIES.

Ordinarily this pest is held in control by parasites. When the parasites do not prevent the multiplication of the lice they can be held down by spraying the infested plants with some contact poison as tobacco decoction or kerosene emulsion.

CABBAGE WORM.

The common green cabbage worms that eat the leaves of the cabbage and cauliflower are the larvae of the small yellow, white or spotted butterflies that may be seen flying over the plants during the growing season. The larvae of these butterflies are so nearly alike in appearance and habits that they are hard to distinguish and may all be treated in the same way.

Little or no attention is paid to them in the larger fields, as they seldom become numerous enough there to cause serious damage. The only effectual remedy is to dust on some form of arsenical poison, as Paris green, before the plants are too much matured. There is comparatively little danger in using these remedies on cabbage, as the head is formed from the center, so that what little poison adheres to the plant will be on the old outside leaves rather than in the edible portion of the head.

CUT WORMS.

These insects, too, are the larvae of several different species of moths. Most of these lay the eggs on plants in August or September. The larvae hatch and become partly grown during the fall, then hibernate in the soil till spring, when they are ready to eat the young plants when set. The late crop is not apt to be troubled with these insects, for at the time the plants are set the larvae have become developed, stopped eating, and have gone into the pupal stage.

Probably the best remedy is shallow, late fall plowing. This exposes

the half-grown worms to the frequent freezing and thawing and kills off the larger part of them.

THE HARLEQUIN CABBAGE BUG.

This insect is a true bug, similar to the squash bug, and feeds by sucking the juices. Where this insect is prevalent it is a serious menace to the industry because of the difficulty of combating it. The remedy is to spray with a contact poison, but the insect is difficult to combat, because of its habit of hiding among the leaves. So far the pest has not become general over the State, but has been found in a few places.

CABBAGE MAGGOT.

So far this insect, which is a serious menace to the industry in some parts of the East, has not been reported in this State. The maggot is the larvae of a small fly. The adult lays the eggs on the young plant, near the surface of the ground, and the maggots feed in the stem of the plant under ground and destroy the plant.

FUNGOUS AND BACTERIAL DISEASES

The cabbage in Colorado seems to be almost immune to fungus diseases.

Black rot of cabbage occurs intermittently. Some years the crop has been seriously affected with this disease and, the year following, the same land in cabbage did not show any signs of the disease.

CLUB FOOT.

This dreaded eastern cabbage disease is hardly known in the State. Turnips have occasionally been found affected by the fungus, so that it is probably that, because of some peculiarity of Colorado soils, such as the alkalinity, the fungus does not thrive here.

COST OF GROWING AND AVERAGE PRICE OF CROP.

The cost of growing crops necessarily depends upon the character of the soil, condition of the land, distance from market, etc., so that an exact estimate is hard to make.

The following figures are estimated on the basis of the cost of growing and marketing potatoes and sugar beets as given by the Greeley Commercial Club:

Fertilizer (10 tons per acre)	$ 5.00
Plowing	2.50
Leveling and harrowing	1.00
Seed	.50
Growing plants	1.80
Setting plants	6.00
Cultivation and ditching	2.50
Hoeing	2.00
Irrigating	1.50
Cutting and hauling	10.00
	$32.80

This cost is two dollars and twenty cents less than for potatoes, and twelve dollars and twenty cents less than for sugar beets.

Like all perishable truck crops, the price of cabbages varies inversely with the size of the crop. By far the larger part of the crop is shipped out of the State, so that local consumption makes no difference with the price. Neither does the size of the crop in the State seem to make any material difference in the price, because other competing cabbage-growing districts produce the larger part of the total output.

The following table, taken from the books of one of the potato and cabbage buyers at Greeley, shows the price paid the growers each year for a consecutive period of ten years:

Year 1899	$ .40 per hundred
Year 1900	.50 per hundred
Year 1901	.75 per hundred
Year 1902	.25 per hundred
Year 1903	.40 per hundred
Year 1904	.25 per hundred
Year 1905	.50 per hundred
Year 1906	.25 per hundred
Year 1907	.50 per hundred
Year 1908	.75 per hundred

This makes an average price for ten years of 45.5 cents per hundred pounds. The average yield per acre for the State is difficult to obtain. Theoretically, with from twelve to fifteen thousand plants to the acre, there should be a yield of five pounds per head, or from fifty to seventy-five thousand pounds per acre. In practice, only from fifty to seventy-five per cent. of the plants ever make heads. As many pounds per acre could be obtained by placing the plants much farther apart. Large heads, however, are undesirable for shipping, so the size per head is cut down by thick planting. The actual yield per acre is from fifteen to fifty thousand pounds.

The minimum yield at the average price makes a gross return of about seventy-five dollars per acre and a net return of something over forty dollars. This year some fields near Greeley have brought a gross return of $355.25 per acre.

MARKETS AND STORING.

When the market will permit, the crop is sold direct from the field. Some seasons, however, the market at harvest time is over supplied, so that storing becomes necessary. Several methods of storing are used in various parts of the country. In any case, cabbage for storing should be left in the field as long as possible before harvesting. The heads should be dry and not frozen when handled. Undeveloped heads may be stored in trenches, the roots buried in soil and the tops covered with straw or manure as for seed. In this way many of them will make marketable heads in January or February that were soft in the fall. Mature cabbage may be cut as for market and stored in bins in the potato or onion dugouts, providing plenty of air circulation all around the cabbage is given and the temperature is kept close to the freezing point.

VARIETIES.

It has been found that cabbage, like potatoes, are more satisfactory for market if only a few well-known varieties are grown in a community. At Greeley, Winningstadt, Hollander, and Cross are grown almost exclusively.

The two former varieties are too well known to warrant a description. The true name of the latter is "Ne Plus Ultra," but is much better known as "the Cross" cabbage. This cabbage is the result of an accidental cross made in 1894 between the Winningstadt and Henderson's Excelsior Flat Dutch. These two cabbages are radically different in type, the former being decidedly conical in form and early, while the latter is late and decidedly flat in form. The Cross is as nearly as possible half way between the two parents in season and form, being medium early and nearly globular.

The originator, Mr. John Leavy, of Greeley, says: "To the growers it needs no recommendation, as they willingly paid $10 per pound for the seed. * * * * Its advantages over all the so-called standard varieties are as follows: Fine texture, more solid and compact, crispness, and a heavier yielder than any variety grown at Greeley." Though this cabbage has been grown from select seed heads since 1895, there is still a tendency to revert to one or the other of the parents. Each year, while the majority of the heads in the field will be globe-shaped, there are many that are conical or flat. This variety has never been listed on the market, except locally at Greeley and Fort Lupton, for notwithstanding the price of seed has been two or three times as high as other varieties, there has never been more than enough seed to supply the local demand.

Bulletin 144 March, 1909

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Colorado Agricultural College

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BY

L. J. REID

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FORT COLLINS, COLORADO
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CELERY GROWING IN COLORADO

By L. J. REID

Climatic conditions in Colorado have made irrigation a necessity and, as a result, we find that the growing of certain crops has been very much specialized. Thus, celery growing has become an important industry in those sections where conditions are such as to make it most profitable. Celery delights in our cool nights and its crispness is improved thereby.

It is only in the last century that celery has become an important article of human diet. The wild celery, a native of the swamps and lowlands of England and Europe, is a small, tough plant of bitter taste. This has been improved by selection and better culture methods until today it is much used on our tables. Since the draining of the muck beds of the Great Lakes, commercial growing has made rapid progress until certain sections have become famous as a result of the extensive raising of this vegetable.

In the vicinity of the largest cities of the state a very intensive system of gardening is carried on. Under these conditions, from two to ten acres are all one man can care for, and even then help must be employed at many times. Those who grow celery in the field during the summer generally grow lettuce, radishes and cucumbers in hotbeds and coldframes during the colder seasons. Some of these beds are used in the spring for the raising of the celery plants.

Soils.—Since celery is a native of moist land, it is natural to suppose that it should be grown on muck soil, and it is true that the largest crops are generally grown in this way. However, it is well known that celery grown on mucky soil is not of as good quality as that grown on firmer ground. Celery growing in Colorado is mostly confined to the river bottom lands, for the reason that these have more sand than is usually found in the uplands; they contain more vegetable matter; are less liable to excessive drying out; and usually the water supply for irrigation is more certain. The ideal celery soil is a rich, loose sandy loam. Owing to our dry climate it has come about naturally that celery growing is confined mostly to those low lying lands where the water is close to the surface, and on soils which never become very dry. Alkali in small quantities does no harm. In fact, some of the best celery land is white with alkali during the winter.

Preparation of the Land.—Since the farms are small, there has been very little crop rotation, but instead heavy manuring has been practiced. A cheap supply of manure is always available in the vicinity of large cities, where the celery gardens are usually located. As a rule, this may be obtained for the hauling, any kind of manure being used, but care must be taken not to apply that which

contains much straw or rubbish, as it interferes with cultivation and irrigation. The grower usually hauls as much manure as he has time to, thus sometimes applying as much as fifteen or twenty loads to the acre. This is the practice of those growing Self-blanching on the heavier bottom lands. The Pascal growers do not manure so heavily, claiming that if they did their upland soils would become too light. However, they often use a few hundred pounds per acre of commercial fertilizer, mostly composed of slaughter house refuse. This is drilled in beside the row during the growing season. A garden drill with an extra large hopper is used for distributing the fertilizer.

The ground is plowed six or eight inches deep and worked into good garden shape before setting the plants. Some practice plowing about twelve inches deep every third year.

VARIETIES.—In commercial growing only two varieties are being used at the present time to any great extent. These are the Golden Self-blanching for the early market, and Giant Pascal for the late market. These supply all that the present market requires, for by proper methods, Golden Self-blanching can be put on the market from early August until the Giant Pascal is ready and this latter can be held as long as it is profitable to keep it in storage. The Golden Self-blanching is not as crisp and tender nor of as good quality as the Giant Pascal, but owing to its earliness, the ease with which it is blanched and the fact that so much more can be grown to an acre, it is far the more important in respect to the amount grown. Pascal celery does not come onto the market until about the first of November and we are entirely dependent on the Self-blanching up to that time.

SEED.—Most of the seed is procured from American dealers, but the growers nearly always ask for French grown seed, because in that country the seed is usually more carefully selected. A few growers have sometimes grown their own seed and obtained excellent results by its use. Sometimes a grower will raise enough seed one year to last him several seasons, preferring to do this rather than use seed bought from unknown sources. So far as the writer knows, there is no one in this section growing his own seed each year. The reason given is not because good seed cannot be grown here, but because the price of seed is so low that it is unprofitable to grow it for sale, and the growers will not go to the bother of keeping plants over winter just for their own seed. Owing to failures as the result of poor seed, it seems as though the use of home grown seed would be more than justified, even though it cost more.

Vitality of seed is quite variable, so it is impossible to figure the number of plants which may be procured from a given amount. It is estimated in buying seed that one can count on 2,500 plants per ounce of seed, but this is very conservative, for some growers

1. Spent hotbeds in which Golden Self-blanching plants are grown.
2. Double rows of Golden Self-blanching, July 3d.
3. Blanching double rows by means of boards. Owing to the field being very level it was necessary to irrigate in the wide spaces between the rows the last time. It is best to always irrigate in the narrow spaces,

get as high as 25,000 stocky plants per ounce when they have good seed. The number of plants suitable for planting depends upon the vitality of the seed and the care of the grower. It is the practice to sow enough seed to secure more plants than will be needed and then select the best of these. Very often a surplus stock can be sold at a good profit, and it is also advisable to have extra plants for re-setting in case of damage to young plants by drought or hail-storm.

RAISING THE PLANTS.—Celery seed is very slow in germinating and sometimes great difficulty is experienced in getting a good stand of plants. Here is where the gardener must ever be on the alert. The seed bed and young plants must never be allowed to become dried out, and yet water must not be allowed to stand on the surface. The young plants are very tender, and a fine spray should be used in watering them. The seed is sown broadcast in the beds or sometimes in very shallow drills four or six inches apart. The seed should be covered very lightly, if at all. Germination will take place in about three weeks.

The Golden Self-blanching celery is usually sown between March 1st and 15th in mild hotbeds from which have been taken one or two crops of radishes or lettuce. These beds are made with about one foot of manure, over which is spread between six and twelve inches of soil, and the whole is covered with glass sash. By the time one or two crops of lettuce have been taken from a bed, the manure does not give a strong heat, but just enough to protect on frosty nights. If one desires this celery for the August market, it is quite necessary that some artificial heat of this sort be given the seed bed, but fresh beds should be used only with great care or the plants will not be strong. For later sowing of the seed, frames simply covered with sash may be used.

The Pascal celery is mostly sown between April 1st and 15th in frames under cloth, although a great deal is sown in the open ground. The advantages of growing under cloth are that the soil is kept from drying out and the young plants are protected from extremes of temperature. It is not considered profitable to transplant celery, so it is left in the original beds until ready for setting in the field, although much more stocky plants may be secured by giving an extra shift.

When the plants are grown in hotbeds, as many as eight thousand are sometimes raised under a three by six-foot sash. However, when less expensive beds are used, it is better to use more room, as one thus gets far stockier plants. Many growers sow one-fourth ounce of seed to one sash three by six feet, but this crowds the plants somewhat. It is very important that the plants be carefully "hardened off." This is done by gradually getting them accustomed to the wind and sun. The sash is raised more and more each pleasant day until the plants can stand to be entirely uncovered. It is very

important that they should never be allowed to become cold enough to be frosted, as this no doubt is one of the principal causes of going to seed.

Several methods are in use for making the plants stocky. Transplanting has already been mentioned, but this is an expensive process. Clipping the tops off lightly once or twice while in the beds is practiced to quite an extent. A few growers have a knife so mounted on wheels that it can be run under the plants, so as to cut off the tap root, thus causing more side roots to develop.

SETTING OF PLANTS IN THE FIELD.—When the ground has been thoroughly prepared and danger of frost is over, the plants may be set in the field. If an early crop is desired it is, of course, necessary that the plants be set early, so as to give them as much time as possible to get their full growth. If the plants are crowded in the seed bed, it is a good practice to thin them and use the plants removed for the first setting. This gives the remaining plants a better chance.

A small furrow is made and the irrigating water is turned into it. This settles the soil and puts it in good condition for setting the plants. After the water has seeped out of the ditch it is the plan of most growers to run a small stream into the furrow again. The surface of the water this second time leaves a line along the edge of the furrow and the plants are set along this line, thus making them all at the same level. In this way none of the young plants are covered when irrigated, and yet all are close to the water. Where Self-blanching is grown, a row is set on each side of the furrow, making two rows about twelve inches apart. Where Giant Pascal is raised, plants are set only on one side of the furrow, and that on the south side if the furrows run east and west, so that the plants may escape the reflection of the sun's rays from the water. The furrows are made about four feet apart. The plants are set from six to eight inches apart in the row. With single rows four feet apart, plants eight inches apart in the row, 16,710 plants would be required per acre; with plants six inches apart in the row, 21,780 plants would be used per acre. When Self-blanching is grown in double rows, just double this number of plants would be used. It is well to have an abundance of plants so that later on any vacant places may be filled.

The beds are watered very thoroughly before removing the plants for setting, and then the plants may be pulled out singly by the roots if it is desired to thin the beds somewhat. The plants are arranged in bunches which can be held conveniently in the left hand. They are put in a box over which is thrown a wet sack to protect from the sun while being carried to the field. In setting, some simply lay a plant on the first finger of the right hand and stick it into the mud on the side of the furrow; others, where the soil

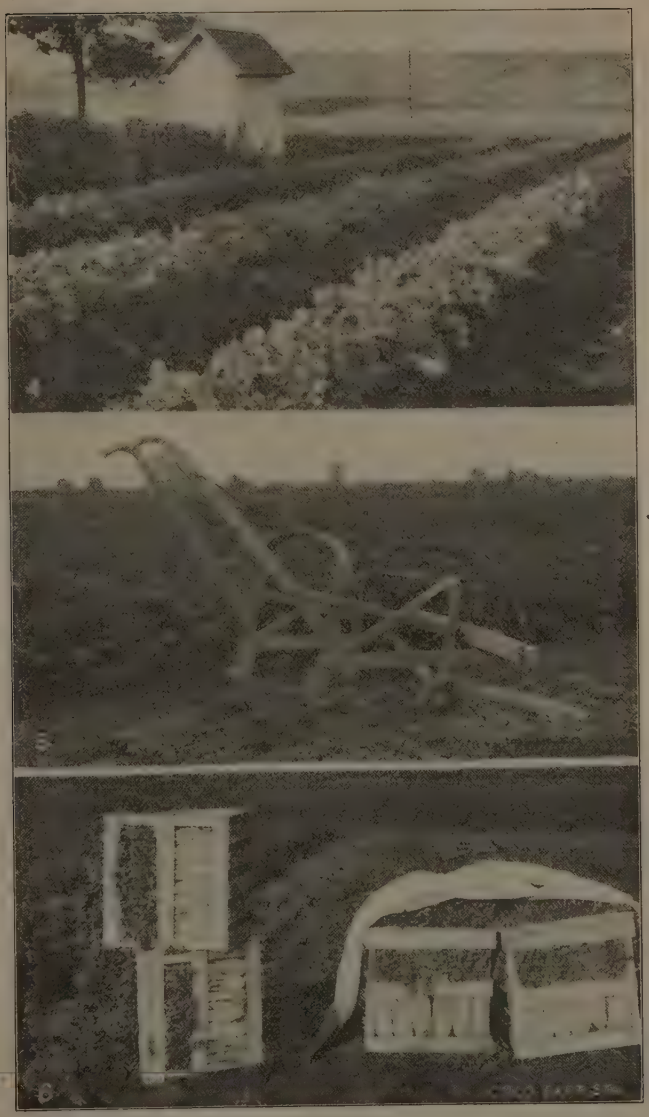
is heavier, make a hole in the soil with a pointed dibble held in the right hand and place a plant in the hole with the left, the dibble then being stuck into the soil beside the plant to close the hole. It is a good plan to wet the roots with puddled mud just before starting to set a handful. There is quite a knack and a whole lot of hard work in setting, but it can be learned much more quickly by watching a good workman and by doing it oneself than by reading how to do it.

CULTIVATION.—Since celery is transplanted to fields which are clean of weeds, the plants have the start of the weeds. However, it is generally necessary to give one or two hand weedings. A wheel hoe is used once or twice, and four or more cultivations are given with the horse and a harrow-tooth cultivator in the wide spaces. Some make a practice of cultivating once a week during the growing season. Those who blanch with dirt often use a five-tooth cultivator the last time or two, so setting the teeth as to throw some dirt toward the rows.

IRRIGATION.—Concerning irrigation each grower has his own ideas as the result of his experience under his particular conditions. Some do not irrigate more than two or three times during the season. Others irrigate nearly every week, commencing at the time of setting. On sandy, well-drained soils it is necessary to irrigate very often. One must use his own judgment, always remembering that celery grows in swamps in its natural condition and, therefore, cannot stand drought.

During the growing season the water is run in the furrows which were made at the time of setting the plants. If double rows are used, as soon as the crop has a good start this furrow will be completely hid by the tops of the plants, but the water will still follow the ditches in good shape if they have been kept clean of weeds. Since the ditch at this time is shaded by the plants, the soil dries out less rapidly and does not bake so badly.

BLANCHING.—Blanching consists in so excluding the light that tender stalks free from coloring matter may be obtained. Self-blanching varieties for the early market are blanched entirely with boards. The banking of celery high with earth during the hot summer days sometimes hurts the crop. Blanching with boards keeps the celery cleaner, but is quite expensive, owing to the great cost of lumber, so it is generally practiced only for a part of the early crop. Boards twelve or fourteen inches wide by any convenient length, usually sixteen feet, are used. It takes about twenty thousand feet of lumber to blanch an acre at one time, but since during the warm part of the year the blanching will be completed in about three weeks, the boards may be used to blanch a second lot. If the boards are carefully piled each year so they will not warp and



4. Blanching by means of earth.
5. A double row digger made by a local blacksmith
6. Crates of Golden Self-blanching ready for shipment.

are protected from the weather in some way, they will last many years. The manner of their use may be seen in one of the illustrations. Some use wire hooks to hold the boards together instead of using stakes.

By far the largest part of the crop each year is blanched by means of earth. One horse is used on a celery hiller, which runs between the rows and throws the dirt against the plants. It is generally necessary to run this machine through twice in order to do a good job, and some times two horses must be used tandem to pull the hiller. Some growers like to finish the earthing with shovels or hand tools, but this adds to the expense. The celery hiller has iron rods so fixed as to lift the leaves out of the way so they will not become covered with earth. About four weeks are necessary for blanching with earth in the field.

For later use a great deal of celery is left to grow in the field as long as there is no danger of frost, and then removed to trenches for blanching. Giant Pascal is either blanched in this way or is partly blanched in the field by means of "papering," and then removed to the trenches. A great deal of self-blanching is also blanched in trenches. The celery is removed from the row, without trimming the roots too closely, and put into long, narrow trenches, so that about two-thirds of the plant will be below the level of the ground. From twelve to eighteen inches is as wide as the trenches should be made, for, if too large quantities are stored together, there is danger of loss from heating. The tops of the plants are covered with light material only as there is danger of freezing. When extreme cold weather comes, earth must be used for protection. Careful watch must be kept to see that the celery does not spoil from being covered too deeply, and yet, if it is allowed to become frozen to any great extent, it will be unsalable. As soon as the plants are set in the trench, water is turned in and a thorough irrigation is given. This will usually furnish enough moisture for the crop until it is ready for the market. If, as is often the case with Giant Pascal, the celery is not dug until late and is to be kept far into the winter, a second or a third irrigation may be necessary in dry seasons.

There is a limited market for "papered" Giant Pascal celery. By this is meant the wrapping of each plant in paper during the latter part of the growing season. This work is commenced in August, and boys are usually hired to do it at two and one-half cents per dozen plants wrapped. Old daily papers are used, and one string holds the paper in place. It is important that this work be postponed until the celery is high enough so that the tops of the leaves will be above the paper after wrapping. Old papers can be bought for eight or ten dollars per ton. As soon as there is danger of frost the celery is dug, put in trenches, and handled in the same

way as the other; but has, however, the advantage of being cleaner and is already partly blanched.

STORING.—Since the California and Florida crops get onto the market during the winter and spring, it has not been found profitable to store celery for any great length of time. In some states large celery storehouses have been used for keeping celery during the winter. In Colorado, there are few weeks during the winter but what it is possible to dig celery from the trenches and get it onto the market. However, considerable is lost in the trenches by freezing and occasionally the weather stays so severe that it is impossible to get the celery out to supply the demand. It is quite probable, therefore, that storehouses will be used to a considerable extent in the near future.

HARVESTING AND MARKETING.—Where only a small area is devoted to celery, the plants are usually loosened from the ground by means of a spade. The roots are cut off and the plant is laid to one side. Where the acreage is larger, especially where soil is used entirely for blanching, a celery digger is used. Different styles of home-made machines are being used for this purpose, but the principle of them all is to run an edged tool just under the plant, thus cutting off the root so it can be taken up by hand. One of these machines for use in loosening a double row is shown in an illustration.

Golden Self-blanching celery is usually "shipped in the rough." A few of the outside leaves are removed and the celery is packed directly into crates, as shown in an illustration. The number of dozen plants in the crate is marked on the outside, the side of the crate is nailed, and the crate is ready for the car. These crates are usually 20x22 inches by 24 inches deep. As can be seen in the illustration, the top is entirely open, except for a strip along each edge. When celery is to be packed for "shipment in the rough," one of the other sides is left open so that the plants may be packed in from the side. The remaining side is then nailed on and the celery is thus held securely in place A crate will hold from four to seven dozen of celery, according to its size at the time of marketing.

Most of the Pascal celery and some of the Self-blanching is carefully trimmed, washed, and tied in bunches of twelve before marketing. In this case the crates are lined with paper before the celery is laid in them. All celery must be washed, bunched, and trimmed before it gets to the retailer, and if this is not done by the grower it must be done by the commission merchant. Some dump the celery into a washing tank and scrub the dirt off by means of hand brushes. Others place the celery in a rack with sides of woven wire, the rack being so pivoted that it can be turned over. A hose is turned on and the dirt washed off. The rack is then turned over and the celery is washed on the other side. Of course, all of the soft outer leaves are pulled off of each plant before washing and the root is trimmed down to a pointed shape. For convenience in bunching, pegs are stuck into holes

in the table or two small boards are fixed so that the celery can be held in a neat bunch of twelve until tied with a string or tape.

Colorado celery is mostly shipped south and east. Texas takes a great many cars, and Kansas City, New Orleans and St. Louis are good markets. During the season of 1908 shipments were made as far east as Pittsburg. The crop is marketed through commission men and through fruit and vegetable associations.

Cost of Growing.—The cost of growing depends on the value of the land, the kind of celery grown, amount grown on an acre, methods of handling and methods of marketing. It can readily be seen that there is more expense in raising forty thousand early plants to the acre than in raising thirty thousand for the late market. It costs more to get the crop ready for the market, because the plants have to be raised under glass and the crop will most likely be blanched with boards. However, the early crop commands a considerable higher price than that which is marketed later.

Some growers claim that $70 per acre will cover cost of manuring, plowing, growing plants, setting, irrigating and harvesting, when shipped in the rough. This does not include rent of land. However, the expense is liable to run considerable higher than this, especially if the crop is blanched with papers, or if it is trenched, washed and bunched before marketing. In the latter case expenses may frequently run over $150 per acre. Of course, if prepared in this way, one should get enough to pay for the extra work. Eastern growers sometimes expend as high as $400 per acre on this crop, largely due to the great cost of commercial fertilizers and manures.

If the grower has good success he should be able to sell his crop for $250 per acre even at the low prices of last season. Some growers, when prices have been extra good, have secured over $1,000 per acre for their crop, but this, of course, is exceptional.

Growing for the Local Markets.—At the present time the growing of celery is confined mostly to the vicinity of the large cities which do not have any local growers, and consequently have to ship in all their celery. Since celery wilts rapidly, it could be furnished in much better condition by local growers who, in this way, would be able to secure the best price. Nearly all our towns have at least some river bottom land well adapted for this crop, the principal requirements being a rich soil retentive of moisture with a steady supply of irrigation water.

Diseases and Difficulties in Growing.—There are no serious insect pests to interfere with celery growing in Colorado at the present time.

There is always more or less complaint of pithiness, but even this does not seem to be a serious trouble under our conditions. Under irrigation the crop may be kept growing evenly and steadily and this probably lessens the per cent. of pithy celery. It is, of course, of great advantage to get seed of the best grade, as pithy celery will much more likely result if a poor quality of seed is used.

The greatest drawbacks in celery growing is the production of "seeders." The plants may appear perfectly normal until along in the summer, when they suddenly send up a seed stalk, thus making the plants valueless. It is not an unheard of thing to have one-half of the crop suddenly go in this way. There are many theories as to the cause of this. Many think it is the result of the plants becoming frosted while in the seed bed or in the early part of the season. There is not much question but what a severe freezing may cause a large part of the plants to go to seed the first season. However, it appears that a severe drying out of the young plants may cause the same difficulty. It is generally agreed that a severe check of any sort may cause this trouble, evidently producing the same result as passing through the winter.

One thing which caused considerable failure during the past season was that so many poor plants were set in the field. If we expect to get good marketable celery we must not use small, dwarfed or stunted plants. Celery growing requires very careful, intelligent work in the spring and proper handling throughout the summer, but it gives good returns to him who knows how and is willing to do his part in assisting nature.

Bulletin 145 DECEMBER, 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Dry Land Farming In Eastern Colorado.

(Information Bulletin.)

BY

H. M. COTTRELL

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1910

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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INTRODUCTION.

This bulletin is intended as an aid to settlers, many of whom have been coming into Eastern Colorado, attracted by the prospect of cheap land and the hope to develop homes. While there have been successes on the plains, our duty would not be performed to the proposed settlers nor to the State without a word of caution. The important thing for the plains is not so much a large settlement as the success of those who do come. It should not be forgotten that there are many chances of failure. This is not entirely due to the country, for many are not able, or do not care, to adapt themselves to the conditions. Experience indicates that the best hope of success is to be found in dairying and in poultry growing, with crops as an important adjunct, grown principally for forage.

It is well that each intending settler should see the plains, learn the difficulties, satisfy himself whether he is adapted to them. I would not discourage such, but those who do not understand the conditions, who are not adapted to them, or who do not have capital enough to tide over one or more unfavorable years are apt to meet with bitter disappointment. Sometimes the impression has been disseminated that some newly discovered practice termed "scientific" has overcome the previous difficulties and lessened the dangers or that there has been a change in climate. This is misleading to say the least. No practice lessens the need that plants have for water though there may be better use of what is to be had.

The principles are those of good cultivation everywhere. Aid should be made of every favorable condition, and then there will be years of hardships. The use of irrigation from wells, by pumping, the collection of floods in draws or gulches, the building of ditches to hold the runoff waters and give time for them to be absorbed, may serve as additional aids of considerable value and help to tide over unfavorable seasons.

For those who meet the conditions with patience and intelligence there may be abundant success.

L. G. CARPENTER, Director.

Dry Land Farming In Eastern Colorado

BY H. M. COTTRELL.

Dry land farming is a continual fight against relentless, unfavorable conditions. Success depends upon the man; his courage, his knowledge and judgment, and his persistence. Physical strength and endurance of both men and women is a large factor in this struggle. With the best seeds and methods of tillage there will be some years of total failure and many others of short crops. It is safest to lay plans that will furnish a living with an average of two failures each five years. There have been three consecutive years of no crops followed by as many years of good crops.

Conditions are much more favorable than they were twenty or even ten years ago. There has been no increase in the rainfall, but the methods of storing and holding moisture in the soil are better understood. Today there are dry land plants that will produce crops with limited rainfall and seeds of these crops that have been selected and bred under arid conditions.

Thousands of failures have occurred on the Plains that have been due to other than climatic causes. Men came and used seeds and methods adapted only to humid regions and persisted in the face of continuous failures until they lost their all. Men came without the capital absolutely necessary to carry them over poor years, and their first seasons were ones of severe drought. Men arrived with families, and after paying the freight on their few household goods had no money left. They had not been thrifty enough to save anything in a humid country, where they had been familiar with profitable methods from childhood. They started in an arid climate, penniless, without any knowledge of the methods needed, and with seed, feed and family supplies to be purchased for from six months to two years before any revenue could be expected. Men came with little money to raise grain exclusively. The surest income in eastern Colorado is made from dairying and poultry.

A man unfamiliar with dry land farming should not settle on the Plains unless he has sufficient capital to erect the buildings that are absolutely necessary, to buy the needed teams and implements, and after making these expenditures, have sufficient money left to pay for seed, feed and living expenses for two years.

Men have taken claims in eastern Colorado who had little or

no money, and after years of pinching and hard work have secured a comfortable home and good living. They have been men of dogged perseverance and good judgment, and usually their families have suffered hardships which no man has a right to ask of his wife and children. Thousands of other men have come with little money; their first years were during drought, and after losing their little, moved eastward, often with the help of friends.

After selecting land and erecting a temporary stable, the new settler should either rent a house or live in a tent until he has secured a good well. In many cases comfortable houses and stables have been built and a good acreage broken, all to be finally abandoned and the investment lost because no water could be secured on the farm.

In some places on the Plains the underground water seems to exist in narrow strips with wide areas on each side without water In other places, the underground water can be secured wherever wells are dug deep enough to tap the sheet water. There is little information that will enable the new settler to form any idea as to what the difficulties in most localities will be in finding water, and as the Plains of eastern Colorado cover an area as great as the State of Ohio, there is a wide variety in conditions. Two neighbors took adjoining claims, and after erecting buildings, breaking ground and putting in crops, hauling all water three miles, started to dig wells. One man put down twelve holes without finding water. The other man found water in his eleventh well, and it was half a mile from his buildings.

After a good well has been secured, permanent buildings may be constructed and land broken and crops planted. The living should be made from dairy cattle and poultry and the methods suggested in this bulletin followed.

The new settler had better break up and seed not over forty acres until he has learned how to farm under dry land conditions, and he should till this thoroughly. Ordinarily, three hundred and twenty acres of dry land will be needed to comfortably support a family. A good arrangement for this is eighty acres in growing crops, eighty acres in summer fallow, or part in summer fallow, and part in crops intensely cultivated, and one hundred and sixty acres in grass. With this amount of land it will often be profitable to rent a winter pasture.

In most dry land counties there are farmers who have lived on their farms for many years, studied local conditions carefully and have comfortable homes with fruit, garden and shade. The new settler should get acquainted with such men at once and should watch and study their operations month by month. The average old settler has not succeeded in making much of a home and usually what he does and says discourages the new neighbor.

The Director of the Colorado Experiment Station, Fort Collins, and the Superintendent of the U. S. Dry Land Experiment Station,

Akron, Colorado, will be glad to furnish any information they or their associates may have and should be consulted often. Reliable books on Dry Land Farming should be thoroughly studied.

Every advantage should be taken of natural conditions. Draws and the lower areas of high uplands can be prepared for garden, fruit trees or alfalfa. Often many acres can be watered from higher prairie lands by running furrows through the sod to catch the storm water as it runs off. It is well to look for such opportunities when selecting a farm. It takes several years to get prairie sod in good condition, but with thorough tillage the tilth and the water-holding capacity increase each year.

THE SYSTEM OF FARMING TO FOLLOW.

Exclusive grain growing in dry land farming has been a failure wherever tried during the past thirty years in Kansas, Nebraska, Minnesota, the Dakotas and Colorado. Yet most of the settlers on the dry lands of eastern Colorado, in the past three years, came with the idea of growing grain only. Many have boasted that they did not even keep a cow for milk.

Hundreds of these grain growers have failed, lost their homesteads and what money they brought with them, and have had to leave the state, sometimes with the help of eastern friends. They made the inevitable failure which was certain to come from their disregard of the experiences of tens of thousands of farmers who had worked under similar conditions. This makes the third time that eastern Colorado has been settled and then almost depopulated.

To many new settlers who are starting in dry land farming on the plains of eastern Colorado, dairying and poultry raising offer a sure income. In the past thirty-four years there have been but few years so dry but that a sufficient quantity of feed could have been raised together with the native grasses to produce a good yield of milk.

Dairying and poultry raising are the profitable lines to follow in dry land farming where the settler's capital is limited, as both give quick and regular cash incomes.

The average annual rainfall on the Colorado Plains varies in different localities from 13 to 19 inches, adequate with good methods, to produce a profitable crop of wheat. In about half the years the rainfall is below these averages, and has dropped as low as 6.93 inches in 12 months, in one section, and in other places to as low as 7.11 to 10.74 inches.

In years of low rainfall, the moisture is not sufficient to produce crops of grain, but there is usually enough for fair yields of forage crops, such as milo maize, sorghum, kafir corn, corn fodder and hay from wheat, oats and barley. These forage crops are not marketable, but become money makers when fed to dairy cows and hens.

Dairy cows and hens, properly selected and handled, will furnish

a comfortable income and enable the farmer to pay cash for his family purchases, no matter how dry the year. Then, the dry land farmer should seed as much land to wheat as he is able to prepare thoroughly with intensive cultivation, and when he raises a crop, the money from it will be surplus cash and will not be needed to pay old store bills, as is the case with the strictly grain farmer.

DAIRYING.

The income in different dairy herds of Colorado ranges from $12 to $120 per cow per year, depending upon the quality of the cows kept and the way they are treated. Careful farmers in the dry land section should make good cows give an average return of $30 to $50 each per year. Many do not get more than $12 per year per cow.

The dry land farmer's supply of feed is constantly limited by the sparse rainfall, and for this reason he needs the dairy cow that will make the most from every pound of feed that he can give her. The selection of the cow is of first concern.

The largest returns in Colorado are being secured from cows of the extreme dairy type and of the Holstein, Jersey, Guernsey and milking Short horn breeds. The unprofitable dairy cows are those that convert most of their feed into flesh and yield a good quantity of milk for a few months only.

Most dry land farmers do not have the money with which to buy pure bred dairy cows, and can not give them the necessary care, shelter and feed. Generally the dry land farmer had better secure his cows from neighboring herds of beef cattle, selecting the cows with dairy forms that are usually found in beef herds. Not always, but as a rule, he will find that such cows are grade short horns.

In selecting range cows for dairy herds there are four essential points:

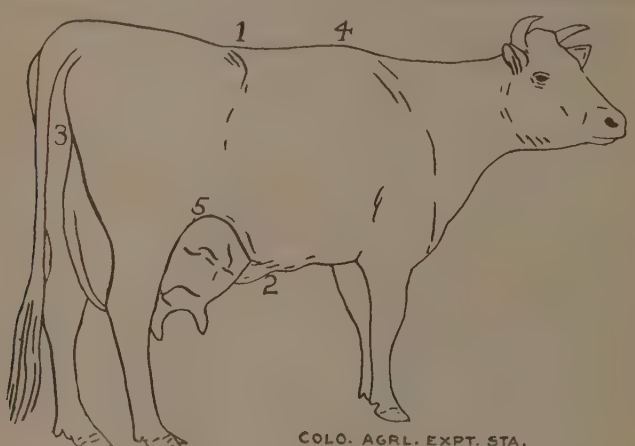
1. *Great Stomach Capacity.* The dry land farmer can feed little grain and his cows must daily eat large quantities of grass or roughage to be profitable. This requires ample room for storage, and to secure it the cow must be deep from back to belly, in front of the hip bones, and broad in the same region. Avoid a round bodied cow whose ribs are short and a flat ribbed cow. The ribs should be long and well sprung, providing for a large paunch.

2. *The cow's back should be sharp* and have little flesh when she is in good condition. When the feed is used to put thick flesh on the back, as is the case with beef cattle, it can not go to produce milk in the udder. The neck, shoulders, rump and thighs should be thin fleshed in the well fed animal.

3. *Ample room for the udder* and a capacious udder when the cow is fresh. The cow should be well cut up behind between the legs so that the udder can extend well up toward the root of the tail. The flank should be well arched, instead of level, as in the beef cow, giving room for the udder, and the udder should extend well forward

and not hang down. The milk veins should be large and the farther they extend forward the better. It is essential that the milk wells the openings through which the milk veins pass into the abdomen should be large, as large as the end of one's middle finger. The udder should be loose and pliable, when empty—not fleshy.

4. *The eyes should be large and bright and project out well from the face.* This is a strong indication of the nerve force needed for strong digestion and large milk secretion.



The dairy cow should be deep and wide from 1 to 2 as this gives her large capacity for rough feed. The back, from 1 to 4, should be sharp, with little flesh, when she is in good condition. She should be well cut up behind so that the udder can extend well up, as at3. Her flank should be well arched, as at 5, to provide room for a large udder.

Where a farmer has handled beef cattle and is not sure he can recognize these features when he sees them, he should go to town and examine several cows that are known to be heavy milkers and verify each point.

Feeding the Cow.

The native grasses of the Plains are good milk producing feeds when abundant. Where sufficient land can be obtained, it pays to have a native grass pasture exclusively for winter use, keeping off all stock during the summer. In the winter of 1907 a new settler in Elbert county had a good winter pasture of native grass, but no other feed for his cows. He sold through the winter an average of four dollars' worth of cream per cow each month. He could not have done this with scant pasture nor poor cows.

Alfalfa is the best dairy feed and the dry land farmer should get

a field on his farm as soon as he can. Corn fodder raised in the high altitudes of eastern Colorado is a good milk producing feed, entirely different from the coarse product of the corn belt. The fodder from kafir corn and sorgum makes a good dairy feed if cut after the plants have headed, and not later than when the seed begins to harden. A full supply of ripe sorghum seed will soon dry up a cow. All fodders should be cut and cured to keep the leaves as green as possible. Hay from wheat, oats or beardless barley makes a good milk feed. The crop should be cut when the seed is in the thick milk and cured with as little exposure to the sun as possible. If there is a low place on the farm upon which the surface water from the unbroken fields can be carried by a few furrows, plant it with stock beets. Feed 10 to 20 pounds per cow daily. Crushed barley, ground wheat and the grain of milo maize are the dry land grains for dairy feed.

A daily variety in feeding forage crops will secure a larger milk yield than the method of feeding one kind exclusively for several weeks and then another. The most profit comes from feeding all the cow will eat every day. Five cows full fed will yield more profit than ten or fifteen cows sparsely fed. Feeding should begin early in the summer or fall before the cows begin to shrink in their milk.

Handling the Cow.

The cow needs in winter a warm, dry shelter, free from draughts. This can be made of straw, or of sod walls and straw or sod roofs, if lumber can not be afforded. Bales of straw will last for years, when used for stable walls, if the top of the walls are protected from rain. The cows in summer should have a shelter from the sun. This should be placed on the highest point in the pasture and can be made by setting up posts and putting over them a straw roof built so high that the cows can not eat it. Such a shelter will furnish shade and will be cool when the wind blows through it.

About 87 per cent. of milk is water, and the cow, to do her best, must have all she wants easily accessible. Salt should be kept in a box where she can eat it at will. Whatever adds to the comfort of a dairy cow increases the yield; discomfort decreases the yield. Kindness increases the milk yield and costs nothing. The more a milker can make a cow love him, as she loves her calf, the more milk she will give. Petting is profitable. The cow should never be driven faster than a slow walk. All feed should be given after milking as the dust from the feed contains the germs which sour the milk. Feeding and milking should be done at exactly the same hours, morning and night. The cow should be milked ten months each year, and on the Plains it is best to let her go dry through February and March.

It will usually pay the new settler to sell the calves for veal, and give all the feed he raises to the cows giving milk, as this will secure the quickest cash returns. A good calf may be raised on skim milk and either shelled corn, the whole grain of milo maize or crushed

barley. The grain should be fed dry and not mixed with the mil Calves need plenty of water.

Handling the Cow's Products.

It will pay to separate the cream from the warm, freshly draw milk with a hand separator. Cleanliness and cold are the necessar means to keep cream sweet. All utensils touched by the milk shoul be washed clean and scalded. No dust or dirt should be allowed t fall into the milk, as they contain the germs which cause souring The cow should be milked in a clean place, and her udder and flank should be clean. Ordinarily cream will keep longer when a covere pail is used in milking. To keep the cream cool, it should be kep either in a pail hung just above the water in a well or else the pai should be covered with a cloth kept wet by having one end dipping into water. Water will rise through the cloth, and constant evapora tion will keep the cream cool. The cream should be sold to a creamery.

In May, 1908, the farmers at a point 90 miles from Denver, re ceived nineteen cents a pound for butter fat, while farmers at a point 50 miles more distant received thirty-one cents a pound. The farm ers receiving the lower price took the offer made by one firm and did not ask for competitive bids. The farmers receiving the higher price secured prices from four competing buyers. Denver, Colorado Springs, and Pueblo are good cream markets, and the producer should search for the responsible buyer who will pay highest.

Twenty dry land farmers around Elizabeth, Elbert county, made an average of $50 per cow per year feeding no grain, but with alfalfa hay. Burke Potter, on a 320-acre dry land farm, at Peyton, received $1,550 in one year for the cream from sixteen cows and six two-year old heifers, and sold veal calves for $50. He has well-bred Holsteins. He paid $300 for bran, and grew all the rest of his feed. With well selected range cows, properly fed and handled, the dry land farmer should average from the sale of cream from $30 to $50 per cow per year.

POULTRY ON DRY LAND FARMS.

The expert Colorado poultryman who thoroughly understands his business and gives strict attention, obtains an average of $2 per hen per year above cost of feed. Every dry land farmer should keep from 100 to 400 laying hens. He will not be able to get as much from them, but his expenses will be less, as a large part of their feed without them would be waste. The hens should be cared for by the farmer, and not by his over-worked wife. They should be fed and cared for three times a day, comfortably sheltered, kept free from vermin and the houses cleaned daily. If the dry land farmer will make a business of poultry, they can be made to bring him several hundred dollars each year. Cash, whether there is a drought or not.

The most money is in eggs from a special egg producing breed and strain. Egg laying strains of general purpose breeds come next in order for profits.

The average Colorado poultry raiser says that his chickens eat their heads off. His flock is a mixture of all ages, all colors and all breeds. Each breed needs a different treatment. Feed that will make a lazy Plymouth rock fat and worthless will stimulate an active Leghorn to heavy laying. The feed required by a laying pullet to provide for both eggs and growth will ruin a three year old hen.

Severe culling is the first step towards profit. Experts estimate that the average Colorado flock produces an average of sixty eggs per hen each year and that where the poorer half of such a flock is culled out, the average will rise to 120 eggs per hen, per year. Culling is particularly important to the new dry land settler, as he needs to make every ounce of feed return a profit, and he can not afford to feed unprofitable poultry.

In the average flock there are old hens that lay none, or few eggs, roosters that are not needed and usually late hatched or stunted pullets that lay little and eat much. These culls usually make up half or more of the flock, and the good layers have to support them.

Feeding Poultry.

During a considerable part of the year hens on the farm will pick up enough waste feed to supply them, but they should be watched every day and fed whenever the waste supply is short. Wheat should form half the ration for the hens, and the other half can be a mixture of milo maize, barley, corn and oats.

When hens do not get all the worms and insects they want they must be fed meat. Meat meal is the cheapest form in which meat for poultry can be bought. Often rabbits are trapped and fed cooked Hens need meat in some form daily, but in moderate quantities. Over feeding is shown by looseness of the bowels. It is a common custom to throw the offal at butchering time where the hens can get it and to let them feed on the carcasses of dead cattle. Almost always in these cases, hens will over eat sufficiently to reduce their egg yield, and if they have not had meat for sometime, will gorge themselves to such an extent as never again to be profitable. This meat is likely to taint the eggs and the flesh. Skim milk and curd will take the place of meat.

Poultry should have access at all times to oyster shells and hard, sharp grit. The Maine Experiment Station found that a laying hen consumed four pounds of oyster shells and two pounds of grit a year. Often it is necessary to buy grit on farms where there is an abundance of gravel and sand, but none with sharp, grinding edges.

Poultry should have all the clean, pure water they will drink at least three times a day. A general cause for well fed hens not laying is lack of water. Sixty-five per cent. of the egg and fifteen per cent.

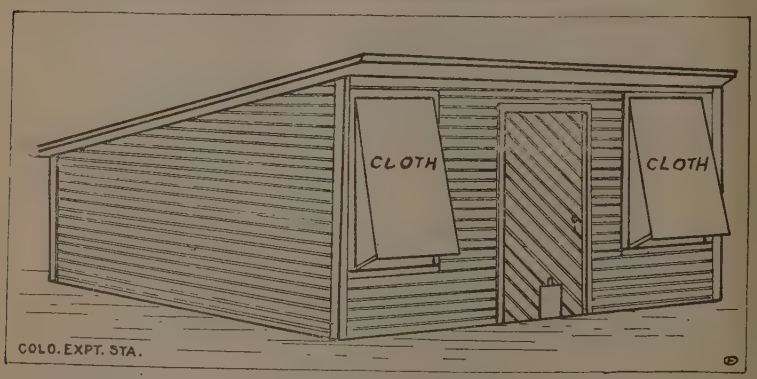
of the hen's body is water, and to lay she must have all she wants, whenever she wants it, and a full supply is necessary in digesting the feed. The chill should be taken off in winter, and the hens watched to see that three times a day they get all they will drink before it becomes frozen. Eating snow is a quick way to stop laying, and walking in the snow will promptly cut down the hen's egg yield.

The hen needs some kind of succulent feed every day; grass, alfalfa leaves, roots, potatoes, cabbage, sprouted grain, or even green sorghum. Too much will make the bowels loose and cut down the egg yield. Just enough should be fed each day to cause the droppings to be similar to those when the hen has the run of a field of grass.

Few good poultrymen feed wet mashes. It pays to warm the grain in winter.

The Hen House.

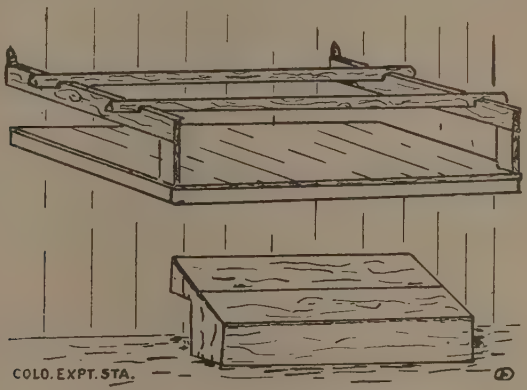
The house for hens should be warm, well lighted, dry and well ventilated without draughts. The dry land farmer can use lumber, sod or straw in building it, and get equally good results from his hens. Good dimensions are four and one-half feet high at the back, seven feet high in front, and fourteen to sixteen feet wide, with a shed roof. It is not best to keep over fifty hens in a house, and thirty to forty hens will give better returns The length of the house will vary with the number of hens kept in it. If two roosts are used, allow five inches in length of house for each hen. If three roosts are used allow three and one-half inches in length of house per hen. Under this rule a house for 40 hens should be about 16 feet in length if two roosts are used, and 12 feet when there are three roosts.



Poultry house for 40 hens, 14 feet wide, 16 feet long, 4½ feet high at the back and 7 feet high in front. No openings except in front. Window frames covered with cloth and hinged at top so that they may be pushed out at the bottom, on warm days. A small slide door at the bottom and center of the large door permits the hens to pass in and out.

All roosts should be on the same level and should not be over

thirty inches from the floor. The roosts should be about two inches wide and flat on top with rounded edges. A dirt floor, raised a few inches above the ground outside to keep out water, is as good as boards in the dry climate of the Plains. Eight inches below the roosts should be a tight dropping board to catch the droppings and they should be raked off each day into a basket and taken away from the house. The dropping board can be made cheaply from dry goods boxes.



Roosts and Dropping board with nests underneath. The hens enter the nests at the back and when on the nests are in darkness. The top over the nests is sloping so that the hens cannot roost on it and is hinged so that the eggs may be easily reached.

The important point in Colorado is to secure thorough ventilation in the hen house without draught. The average daily change in temperature each twenty-four hours is twenty degrees, and with such a great change it is difficult to ventilate through tubes or open windows without draughts. A draught on a hen is sure to cut down the egg yield, and usually brings disease. To prevent draught, have the house face the south. Make the north side, roof, and east and west ends without openings or cracks of any kind. Use heavy muslin in place of glass for windows. The air will circulate through the cloth without any draught, and light will pass through as well. Arrange the nests so that when the hens are on them, they will be in the dark. Keep the eggs in a cool, dry, dark place.

Hens on the treeless plains need cool shade in summer; sunflowers, trees or any low straw shed open on the north and south sides will supply this.

Lice and Mites.

Lice and mites thrive particularly on the Plains, and a persistent fight has to be made against them the year round. The dropping

board below the roosts should be cleaned daily, and the whole house once a week. The hens should have a good dust bath always ready, and two or three times a year the house should be white-washed inside, and carbolic acid mixed with the white-wash. Insect powder or tobacco dust dusted on and worked down through the feathers to the skin will kill body lice. Applications of boiling water or lice killer to the roosts and to all the woodwork, and particularly in the cracks, will kill the mites. Scald the nests with boiling water, as the lice killer will taint the eggs. Dr. J. W. Downey, one of the best poutrymen in Colorado, makes a good lice killer by crushing moth balls and dissolving them in kerosene. The liquid from this mixture is very inflammable and must not be used where there is a light of any kind. It is as effective as the patent lice killers and much cheaper.

It takes hard, intelligent work to make money from poultry on the Plains, but if the new settler is willing to give the necessary attention, he is sure to have the money with which to buy the family groceries whether it rains or not. Even with every pound of feed purchased, a good poultryman can make money in Colorado, and in most years the dry land farmer can provide most of the feed.

THE DRY LAND GARDEN.

The garden should be located where it can be irrigated from the well or where storm water from the prairie can be brought onto it by means of furrows. The patch should be small and should be given much cultivation. In most soils a garden can not be irrigated by taking water directly from the pump to the ground. A few square feet of ground will absorb water as fast as an ordinary windmill can deliver it. The water must be collected in a tank or earth reservoir, and then turned on in a considerable sized stream that will flow the entire length of the rows.

When ready to irrigate, open a narrow furrow along the entire length of the row and a short distance from it. Pull a straight round post through this ditch, to smooth the ground, and then run the ditch full of water. Apply the water after sundown, as it will do more good then, and the next morning thoroughly cultivate the soil, making a good earth mulch.

Mr. J. E. Payne, Superintendent of the U. S. Dry Land Experiment Station, Akron, Colorado, recommends that all garden crops be planted in rows and thoroughly cultivated. He recommends planting the usual small truck and a good patch of Mexican beans, early cow peas, sweet corn, potatoes, pumpkins, squashes, melons, and Pearl or Queen's Golden pop corn. He recommends planting seven varieties of sweet corn: Cory, Black Mexican, Perry's Hybrid, Stowell's Evergreen, Country Gentlemen, Mammoth Evergreen and Egyptian. He plants all varieties the same day, often near the last of May, and has had roasting ears from July 26th to September 26th. "Sweet corn can be dried; the ripe grains parched are a luxury, as is popcorn

and milk. Poultry will keep the grasshoppers down, and potato and squash bugs may be killed by a club. A constant fight against them is necessary."

Early Richmond Cherries resist drought well and the fruit ripens while supplied with spring moisture. Set them 20x20 feet apart. Prof. B. C. Buffum recommends horse radish and rhubarb as among the strongest drought resisters. Mr. Payne states that gooseberries, native currents, plums and cherries are reasonably sure to produce good crops if given special care.

RAIN FALL IN COLORADO.

Records furnished by Prof. L. G. Carpenter, Director, Colorado Experiment Station, Fort Collins.

TOWN AND COUNTY	No. Years Record Kept	Average Inches Rainfall 3 Winter Months	Average Inches Rainfall 3 Spring Months	Average Inches Rainfall 3 Summer Months	Average Inches Rainfall 3 Fall Months	Average annual Rainfall, Inches	No. of Years Rainfall was below average	Least Rainfall in One Year
Rocky Ford, Otero	19	1.13	4.10	5.50	2.11	12.84	11	6.93
Denver,	39	1.62	5.53	4.27	2.53	13.96	18	8.48
Hamps, Elbert	15	0.91	5.21	6.15	1.69	13.96	10	7.62
Fort Collins, Larimer	25	1.37	6.24	4.63	2.63	14.87	13	7.11
Cheyenne Wells, Cheyenne	15	0.93	5.27	7.88	2.35	16.43	6	8.41
Le Roy, Logan	19	1.46	6.06	6.72	2.44	16.68	11	7.34
Yuma, Yuma	18	1.70	6.05	7.63	2.41	17.79	8	10.34
Wray, Yuma	14	1.09	6.43	8.29	2.85	18.66	5	10.74

HANDLING THE SOIL.

Only the principles of handling the soil can be given. Their application will vary each year on every farm and with each crop. The dry land farmer's success will depend upon his skill in applying them to each individual crop.

The best soil for dry land farming is a sandy loam, then a light clay loam, and next a sandy soil. An adobe soil is to be avoided, as is also one with a coarse gravel subsoil.

The soils of the Plains are rich in mineral plant food. Often the subsoil, to a depth of thirty feet or more, will produce good crops when brought to the surface. The yield of the crop is determined by the quantity of available water which passes through the plant. Often when the rainfall is ample for a full crop, none is raised because the soil is in such condition that the rain can not be absorbed and the water runs off into the streams. Frequently when the soil has absorbed a plentiful supply of moisture to produce a good crop, the yield is unprofitable, because a soil mulch has not been provided, and the water is lost through evaporation.

WATER USED BY CROPS.

Prof. F. H. King concludes from his researches and from those of other investigators that an average of three hundred and twenty-five pounds of water must pass through the plants, and be evaporated by them, for each pound of dry matter which they produce. The weight of an inch of rainfall on an acre is one hundred and thirteen tons. In a crop of wheat grown on dry land, there is about the same weight of dry matter in the straw as in the grain. On this basis, one inch of water passing through the plants is sufficient for about five bushels of wheat per acre.

Under fair dry land conditions, at least three-fourths of the annual rainfall evaporates from the surface and runs off into the streams, with most skillful management this leaves not to exceed one-fourth of the rainfall to be absorbed by the plants. An annual rainfall of twelve inches, falling at the right time, and carefully conserved, would, under most favorable circumstances, furnish three inches of water to be actually used by the plant—sufficient to produce fifteen bushels of wheat.

It is evident that the production of fifteen bushels of wheat per acre, or the equivalent in other crops, from an annual rainfall of twelve inches, hangs on slender chances. Where the ground is hard or has been plowed too shallow to absorb water well, the run off is large. In some seasons the total rainfall is ample, but does not fall during the growing season, or it comes in heavy, driving showers, so fast and so hard that even mellow, deep soil can not absorb it as rapidly as it falls. The earth mulch may be carelessly maintained, and then the evaporation from the surface of the soil may amount to much more than three-fourths of the rainfall. The seed may be shiftlessly put in, the plants so thick in places that a good supply of moisture is insufficient and so thin in other places that they can not use all the moisture.

On the other hand, the plowing may be so deep and the soil kept in such good tilth that under ordinary conditions much less than one-fourth of the rainfall will run off and a greater proportion left in the soil available for the plant.

Four things are necessary to secure profitable crops with the limited rainfall of eastern Colorado:

1. Storage of rainfall.
2. Retaining moisture in the soil.
3. Reducing the effects of the wind.
4. Drought resisting crops from seed grown under dry land conditions.

STORING RAINFALL.

Much of the rainfall runs off the surface of the compact, unbroken prairie of the Plains. The earliest need is to put the soil in such tilth that it will absorb a large part of the rainfall, even when it comes

in dashing showers. To do this it must be broken and porous, to a depth of at least a foot, and in granular condition—neither loose nor puddled, and with no large air spaces. The surface must be kept corrugated. A soil in this sponge like condition not only absorbs water well, but allows a wide spread of the roots, giving to each plant a large water-supplying area.

The raw prairie is broken the first time at any depth from three to nine inches, depending on the power available and the toughness of the sod. It should be gradually deepened until the practical limit of the ordinary plow is reached. All the land should be plowed, no cutting and covering, and the furrow should be turned over flat and pressed firmly down on the unbroken soil to promote quick rotting. If the plow is followed with a disc harrow, running lengthwise of the furrow, the rotting of the sod is hastened. The soil gets into condition most quickly when the prairie is broken after the grass has started well in the spring and while it is still growing.

One of the cheapest ways to deepen some soils it to take advantage of the effects of frost. Just before the ground freezes in the fall, list it, going as deep as the lister will work and making the rows not over three feet apart. The furrows will soak up all the moisture that falls and the ground will freeze deeper than it would if left level. On warm days the large surface of exposed soil will thaw and in cold nights freeze. This alternate freezing and thawing granulates the soil, putting it in the best condition for absorbing moisture.

The listed ground must be leveled and protected with a soil mulch as soon as the frost is out, as the evaporation from the large surface made by listing will be much greater than with level land.

In twenty-one years of observation on the Plains the writer has never seen any increase in yield with any kind of crop from subsoiling land. The soil does not stay loose long enough after being subsoiled to be benefited. Where a farmer thinks that subsoiling will help his land, he should first test it on a small scale.

Using deep rooted plants, such as alfalfa, brome grass and sweet clover, is a cheap method of deeply loosening hard soils and thereby improving their water-holding capacities.

Decayed plant and animal matter increases the water-holding power of the soil, and the dryer the season the stronger its influence. This material gives the soil a dark color and is very deficient in the soils of the Plains. The more the decayed roots of plants and the material from rotted manure is incorporated into dry lands soils, the greater will be the proportion of rainfall that is absorbed.

It is specially important for storing moisture in dry land farming that every pound of manure produced on the farm should be spread on the fields, and yet most dry land farmers find that when they manure the land, the crop is reduced, sometimes for several years. When coarse manure is plowed under, it cuts off the connection between the

plowed and the unstirred soil, making a mulch that prevents the water from rising through the plowed land, and it creates large air spaces in the soil. These tend to dry out the soil rapidly and to weaken the plants growing in it.

All manure used in dry land farming should be applied as a light top dressing to grain, grasses or alfalfa. It then acts as a mulch, helping to retain moisture in the soil. The finer particles are imperceptibly absorbed by the soil, the harrowings required by these crops slowly work the manure into the soil without making air spaces and the manure becomes as great a help as it is a detriment when plowed under unrotted.

RETAINING MOISTURE IN THE SOIL.

When dry land soil has been loosened to a good depth to form a reservoir, and it is porous and fine grained, the water from a rain slowly moves downward through it until absorbed, and each minute grain of earth becomes covered with an invisible film of moisture.

When these minute grains of soil are in close contact with one another, there is a constant movement of the water in the films surrounding them, the water flowing from a wet grain to a dryer one. After a rain the sun and the wind dry out the surface soil and carry away the moisture contained in it. Then the water from the damper soil below moves upward to wet the surface grains and is in turn evaporated. This movement continues in land not cultivated and extends to a depth of many feet, often, in a dry time, taking out of the soil, in a week moisture equal to more than an inch of rainfall.

When the surface soil is stirred after a rain, the tiny grains are separated so that the water does not easily pass from one to another. The movement of the moisture is checked and evaporation is greatly reduced. Such shallow cultivation is called an earth mulch, because it has a similar effect in holding the moisture in the soil, as that effected by a mulch of straw or a covering of boards.

The dry land farmer's supply of moisture for his crops depends upon his skill and judgment in maintaining an earth mulch over his cultivated fields. No set rules can be given. He should study the principles governing the absorption and movement of water in the soil, as here given, until he thoroughly understands and appreciates them. Then he can intelligently conduct the farm operations for maintaining the earth mulch.

The deeper the earth mulch, the better it will prevent evaporation from the soil. For cultivated crops a general rule, with many exceptions, is to keep the mulch three inches in depth. With trees, four to six inches is better. Seeds must be planted below the earth mulch so that they will be in moist soil and the mulch must not be so deep as to prevent the young plants from coming up. With growing wheat and other grains, the mulch must not be made so deep as to put the roots in dry soil.

A good rain packs the loose surface soil and destroys the earth

mulch. It is necessary to pulverise the ground quickly after every such rain to restore the earth mulch, as a week's delay may mean the loss of water equal to an inch of rainfall. Light showers do not usually destroy the mulch.

On account of the winds, evaporation is very rapid just after the frost goes out of the ground in the spring and an earth mulch should be established as soon as the ground is dry enough to work. Evaporation is very rapid from stubble fields after the grain has been cut, and an earth mulch should be made with a disc harrow as soon as the grain is shocked.

Where the surface is hard, the earth mulch will have to be made with a disc harrow; where the surface is mellow, a spike toothed harrow will pulverize the soil sufficiently. A four-horse disc harrow should be used for economy of time. A man having five horses attached to a twenty-four foot spike tooth harrow can put a mulch on thirty to sixty acres a day.

When the annual rainfall drops much below twelve inches and the rainfall during the growing season below five inches, it is difficult, and often impossible, to raise a profitable crop. The land can be fallowed one season and cropped the next, the one crop having the use of what moisture can be stored from two years' rainfall. During the season that no crop is raised an earth mulch must be maintained, and to do this it is usually necessary to till the surface about every ten days, and always after any considerable rain.

In many seasons paying crops may be secured by this system, where, if an attempt is made to grow crops every year, the failure will be total for both years.

With this system the dry land farmer who has one hundred and sixty acres under cultivation will each year have eighty acres in crops, and eighty acres which he will have to till regularly, but upon which nothing will be growing. In Logan county a farmer has been quite successful in following a modification of this plan. He raises three crops in four years. The first season no crop is grown, but the land is kept thoroughly cultivated. In the fall, winter wheat is sown. After harvest the ground is immediately disked, and, as soon as convenient, plowed and harrowed. The following year corn is planted and well cultivated, the cultivation in part having the same influence as a summer fallow. The following year wheat is grown, and the next year the rotation is started again with a summer fallow for the whole season.

Weeds act as pumps constantly at work taking the water needed for the crops out of the soil and evaporating it into the air.

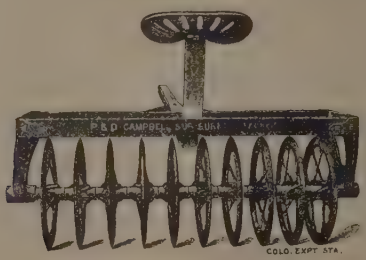
SUB SURFACE PACKING.

Usually on the Plains when soil is turned over with the plow, it is so dry that an imperfect connection is made with the unstirred ground beneath, and the soil that has been broken up by the plow

acts as an earth mulch and prevents the moisture rising above the bottom of the furrow. Unless rain comes, the ground that has been turned by the plow soon becomes so dry that plants will not live in it. It is a good system to thoroughly disk ground just before plowing. The surface turned under will then be fine and will better form a good connection with the soil below.

Dry soil, clods, trash and coarse manure, when turned under by the plow, will make air spaces in the pulverized soil. The air in these spaces dries out the soil and increases the losses from evaporation.

To retain the moisture in the pulverized soil, to bring it up from below to the roots of the plants and to drive out the excess of air, freshly plowed soil must be firmed until a compact but mellow condition is secured. The best implement so far devised with which to do this is the Sub Surface Packer originated by Mr. H. W. Campbell.



The sub surface packer consists of a number of sharp rimmed iron wheels, twenty inches in diameter, placed five inches apart on a strong shaft mounted in a suitable frame. The packer follows the plow, going lengthwise of the furrow. The sharp wheels fine the soil near the surface where the seed is planted and firmly packs the earth against the bottom of the furrow and around the trash and manure,—just the condition needed for a good seed bed and for the best control of the moisture.

The writer considers the sub surface packer one of the most indispensable implements for dry land farming, and would not attempt dry land operations without it. One hundred and sixty acres were plowed for wheat, eighty acres prepared as thoroughly as could be done by harrowing and eighty acres fitted by packing. The yield on the harrowed ground was eighteen bushels per acre, on the packed ground forty bushels.

Whenever the soil is sufficiently moist to settle quickly, it is not necessary to use the packer, but it should be at hand for use when needed. It is heavy in draft, an eight-foot machine requiring four good horses.

Sub surface packing can be fairly well done by setting the disks straight on a disc harrow and weighting the machine to cut deeply.

A corrugater roller is a fair sub surface packer, though not nearly so effective as a machine with sharp rimmed wheels.

With good management in storing the rainfall and in holding it in the soil, the earth will be kept moist from the bottom of the mulch to a depth of 8 to 9 feet.

REDUCING THE EFFECTS OF THE WIND.

A dry land country is always a land with much wind, and the dryer the season the steadier and the harder the wind blows.

The first principle for reducing the damaging effect of the wind is to keep the surface of the ground corrugated. Engineers, in measuring deep mountain streams, often find that where the water is moving so swiftly on the surface that a man can not stand against it, there is almost no current at the bottom, where the velocity is checked by stones. It is on the same principle that the surface of dry land should be kept corrugated; the uneveness impedes the motion of the wind.

When freshly plowed dry land soils are rolled with a smooth roller, the wind moves as fast along the surface of the soil as it does at the height of a man above it, and will often sweep the soil off the field as deeply as it has been plowed.

The sub surface packer leaves the ground more deeply corrugated than the grain drill. The packer wheels have iron spokes, and while the rim fines and packs the soil, making a good seed bed, the spokes bring small clods to the surface, and packed ground has both the corrugations and the clods to retard the wind. The writer has many times seen a highwind blowing across a field that had just been treated with a sub surface packer, and a little fine dust only would be sifting around the clods and across the low ridges, while from adjoining fields, left smooth, the dust was rising in clouds.

All grain should be drilled in with the furrows running at right angles to the prevailing winds.

Deep fall plowing, left rough, will carry land through the winter with reduced losses from blowing, especially if the lower soil that is turned up is a little heavy. An earth mulch must be made on fall plowed ground as early in the spring as it can be worked to save the moisture.

The dry land farmer will find it profitable to start wind breaks and shelter belts around his buildings and garden as soon as his farm gets on a living basis. It sometimes pays to have them on the north, west, and south sides of the farm to check the wind's force. Professor Longyear, of the Colorado Experiment Station, recommends using two year old seedling trees, planting them eight feet apart each way. The two outer rows to consist of Russian olive, the third and fourth rows of black or honey locust, the fifth and sixth rows of ash, the seventh and eighth rows of American Elm or Golden Russian willow, and the two inner rows of cottonwood or Carolina Poplar.

Full directions for the planting and after treatment of forest trees may be obtained by writing to the Director of the Colorado Experiment Station, Fort Collins.

CROPS FOR DRY LAND FARMING.

It is imperative that the seed used on the Plains should be grown under arid conditions. It is best to use seed that has been grown in the neighboorhood where it is to be planted. If this is impossible, the seed should be grown under as dry conditions as will be met by the growing crop.

This fact can not be emphasized too strongly. Even a small increase in the amount of moisture will lessen the power of plants to withstand severe drought. In a dry year in the "nineties" the writer inspected a field of corn on a farm where the line fence was on the State line between Colorado and Kansas. The stalks were green and well eared, while for over one hundred and fifty miles east, corn was generally a failure. The seed used was a local strain that had, by selection, been developed to yield well under local dry conditions. The grower stated that every time he had tried seed from even only one hundred miles farther east, the crop had been poor.

It is the common practice for new dry land settlers to bring their favorite seeds with them. The Iowa man brings seed corn, the Indiana man oats, and the Michigan man potatoes. With seasons of average or lower rainfall, the planting of these eastern seeds guarantees a failure. The root development of plants from eastern seed is not sufficient to enable them to spread far enough in dry land soil to gather enough moisture, and often the too great growth of foliage evaporates too much moisture.

Only those grain crops that mature early, before drought and hot winds come, and before the spring moisture is exhausted, should be grown. Wheat, barley and speltz are such crops. The surest forage crops are those like sorghum, milo maize and kafir corn that live and stand still through a drought and then mature quickly when rain comes. Seed should be selected from plants whose large root systems give them a broad area from which to draw moisture.

Every season it is likely that conditions on the Plains will be unfavorable before the season is over. This condition demands seed with strong vitality that will transmit vigor to the young plants as soon as they start. Heavy seeds, as a rule, give strongest growth and the thorough use of a fanning mill with plenty of air is a great aid in securing a crop.

Dry land farmers are usually careless about seed and use a mixture of heavy, shrunken and cracked grains, weed seed, chaff, sticks and dirt. There is much loss from seed that has been heated.

Thin seeding is necessary. Where there is moisture enough to mature one plant only, if two occupy the space, the crop is a failure.

When in doubt about the quantity of seed needed, use one-half the amount customary for humid sections.

The following pounds per acre are suggested, but the amount should vary with the size of the seed and the condition of the soil:

Wheat, 30 to 40.
Barley, 35 to 50.
Speltz, 45.
Flax, 20.
Millet, 10.
Sorghum drilled for forage, 25.
Kafir corn, drilled for forage, 25 to 30.
Milo Maize, for grain, 5 to 8.
Corn, single seeds, 15 to 18 inches apart.
Dwarf Essex Rape, 3 to 5.
Brome Grass, 20.
Alfalfa, for hay, 12 to 20.
Alfalfa, cultivated for seed, 2 to 3.
Sweet Clover, 20 to 25.

Early seeding should be the rule, so as to take advantage of the moisture released when the ground thaws out and from that furnished by early rains. The development of the native vegetation is a good guide to the time for seeding.

Broadcasting has no place in dry land farming. It is a sure method of wasting seed and of producing many weak plants. Some seed is certain to be put in too deep and more too shallow. All seeds should be drilled and great care should be taken that single seeds are placed at equal distance apart. In careless drilling, where seed is bunched, there is not enough moisture to develop the plants, and the moisture in the bare spots is wasted. The writer has examined fields of corn in dry land sections where in every row there were spaces between stalks of from 5 to 13 feet, and other places where the corn was in bunches too thick to amount to anything. Wheat is often seeded as carelessly, and such planting insures a serious reduction in the crop no matter how favorable the season.

It is self-evident that a good seed bed is essential in dry land farming, and yet it is common practice to put seed in cloddy, dry and loose soils.

Sorghum is the surest drought resisting crop. The yield is from nothing to seven tons per acre, depending upon the condition of the soil at planting, the character of the seed and the rainfall. Early Amber is generally used. The seed may be put in with a grain drill, at the rate of 25 pounds per acre, or listed shallow, six pounds of seed per acre, and cultivated until the furrows are level full. It grows very slowly at first and should not be seeded until the ground is warm, usually May 10th to June 15th. Seeded earlier the weeds get ahead of it. Sorghum should not be cut until the seeds begin to harden. When cut before it heads, sorghum is chiefly water and some vegetable fibre, and while very appetizing, furnishes little nourishment to stock. In years of plenty, sorghum can be stacked and kept until needed in times of drought. A cheap but rather wasteful way for harvesting it is to turn the cattle into the sorghum field when the seeds have become firm. Such a method of fall feeding will hold dairy cows up well in their milk. The cows should be well fed before being turned into the sorghum and left only one hour the first day,

two hours the second day and so on. Sorghum makes a fair pasture for hogs during the summer. A dairy cow fed all the ripe sorghum hay she will eat, and no other feed, will soon go dry. It is a fair dairy feed when supplemented by other fodders.

Kafir corn, the surest dry land grain crop in Kansas and Nebraska, does not mature anywhere on the Plains of Colorado except in Baca county. The high altitude makes the nights too cool and the seasons too short for kafir corn as a grain crop. It is planted for forage the same as sorghum.

Dwarf Milo Maize has the same habits and characteristics as kafir corn, but will ripen in a shorter season, and is probably the surest grain crop for the dry lands of eastern Colorado. It should be tried by every farmer, as it will probably fill the same place in dry land farming that corn does in the corn belt.

On ground well filled with moisture it may be planted with a grain drill in rows thirty-two inches apart, dropping single seeds four to six inches apart in the row. In dryer land it may be listed after the ground becomes warm, from May 10th to June 15th, dropping single seeds the same distance as above. The drill and the lister should be followed with a press wheel to pack the soil over the seed. Milo maize is a sorghum without sugar, the strength of the plant going to produce seed.

The seed should be kept in the head until just before planting. Threshed seed stored in bins or in sacks, even when kept dry for a year, is likely in a few damp days to become sufficiently heated to badly injure its germinating power. Where not over forty acres are to be planted, the heads may be held on a sloping board in a wash tub and the seeds scratched off with a common curry comb. The ripest and the most vigorous seeds will shell off first, and when half the seeds have been rubbed from a head, it may be thrown aside and fed to stock. With this method, only the best seed is secured. It should be cleaned free from stems and chaff before planting.

Milo maize should be given frequent shallow cultivation, the same as corn. When ripe is should be cut and shocked like corn. This may be done either by hand, with a corn sled or with a corn binder. In winter the fodder with the heads may be fed to cattle and horses and the scattering grain picked up by either hens or hogs. Fattening hogs do better when the grain is threshed and fed to them either soaked or ground. Work horses fed milo maize can do as much heavy work in the spring and summer as they can on corn. It is best to top the fodder and feed the grain to work horses in the head. When eating milo maize in the head, the little stems that hold the seeds compel the horse to eat slowly and chew the grain well. When threshed grain is fed, the horse is likely to bolt his feed.

One hundred pounds of Milo Maize have a feeding value equal to ninety pounds of corn, and a fair yield is forty bushels an acre, equal in feeding value to thirty-six bushels of corn. The objection

to milo maize as a feed is that it is constipating and stock after a few weeks feeding on it suffer in consequence. This may be overcome by feeding some alfalfa or flaxstraw, the oil in the few seeds left in the straw acting as a laxative.

The plants of sorghum, kafir corn and milo maize develop large root systems, much larger than corn. This enables each plant to secure moisture from a comparative large area. When a drought comes, these crops live but stand still for weeks, and if late rains come, start quickly and mature seed.

Millet gives a fair yield in seasons where the rainfall reaches the average or above. It is a cheap crop to grow and to harvest and on this account is liked by many dry land farmers. The German millet is the best yielding variety when the rainfall is good. The Broomcorn millet withstands drought best. Millet should be cut as soon as it comes into head, as the ripe seeds are detrimental to stock.

Early cut millet makes a fair feed for cattle, and its laxative effect is beneficial to cattle being fed sorghum, kafir corn or milo maize. Millet hay containing ripe seeds will quickly dry up a dairy cow. Millet, no matter at what stage it is cut, is a dangerous feed to give horses. If fed long, it will stiffen horses so that they will never recover, and often causes their death.

Corn. In years of average rainfall corn is a valuable forage crop in eastern Colorado, and when moisture is abundant, yields a moderate crop of grain. On account of the altitude, the seasons are too short and the nights too cool for large crops. Corn fodder raised at this high altitude is an excellent dairy feed, entirely different from the coarse product of the corn belt.

Seed developed on the Plains must be used; that from the corn belt will not yield much grain in years of heaviest rainfall and in dry years often does not even produce fodder. Frequently new settlers from Iowa and Illinois will send back for seed for three or four years, and every year have a failure before they are willing to accept this fact.

The Plains bred corn has a short, rather sturdy stalk, limited in foliage, and the ears grow close to the ground. The Mexican corn stands the drought best. The ears start at or below the ground, and the variety is objectionable on this account. The White Australian Flint is generally preferred. It is a local variety, bred to withstand drought well, and the ear is similar in character to the eight rowed flint corn of New England. The grain is very hard and needs to be soaked or ground for feeding. The Swadley Dent and the Colorado Yellow varieties have ears similar in size and type to the Pride of the North Corn of Minnesota. They are prized in many localities.

A fair crop of corn on dry land is from 10 to 25 bushels per acre, and this yield is considered profitable on account of the high price of corn in Colorado and the low expense of raising a crop.

Corn and Milo Maize need similar methods of planting and

cultivation, and when the dry land farmer can afford the teams and the implements, one man can handle large areas and reduce the cost per acre for raising so low that even a small yield is profitable.

One man and three heavy horses with a single lister can prepare the ground and plant eight acres a day. Following the lister with a smoothing harrow has never seemed to the writer to be profitable, although generally recommended. About all the harrow does is to drag trash on to the rows.

For the first three cultivations, one man driving four heavy horses on a disc harrow can cultivate twenty acres a day, straddling alternate rows, and each cultivation straddling the row that was on the outside the previous cultivation. Guards are needed to protect the corn when small. One man driving four heavy horses to a three-row lister cultivator for the first three cultivations can handle well thirty acres daily. With both the disc harrow and the lister cultivator, the corn should be laid by with an ordinary corn cultivator. The crop can be harvested at the rate of seven acres a day with a three-horse corn harvester.

Wheat is the cash crop of the Plains, but fails too often to be depended upon to meet living expenses. It is safe to calculate on at least two failures each five years. Sometimes there will be failures for two or three years in succession, and then as many paying crops. It is probable that in many sections the greatest profit could be made by alternating summer fallow with years of cropping.

The ground should be plowed early for wheat, and each half day's plowing harrowed before the teams leave the field. After plowing, the land should be worked with a sub surface packer and then harrowed frequently. Wheat needs a shallow firm seed bed, very mellow above the seed.

Turkey red is the variety preferred for fall seeding, and Kubanka Durum for spring seeding. Early seeding is usually necessary to secure a good yield. The seed should be heavy and well graded and sown with a drill.

In the spring, if the ground is loose, run over it with a sub surface packer. If the ground is firm so that many plants are not loosened, harrow across the drill rows. Begin harrowing as early as the ground will work well, and continue, at intervals of ten days, until the plants shade the ground.

When wheat, after heading, begins to burn up from drought, it may be cut for hay and makes a good feed for horses and dairy cows.

Barley requires a short season and a good supply of moisture for early growth. It should be seeded with a drill as early in the spring as the danger from severe frosts is over. Barley is more sensitive to frost than either wheat or oats, but if the ends only of the leaves are killed, the plants are not hurt. Often the moisture released when the frost goes out of the ground is nearly sufficient for barley up to heading time, when the seed is sown early.

A large share of the failures in growing barley come from late seeding. The seed is sown after the moisture held by the frost has been lost, making the early growth weak. The barley then heads too close to the ground to harvest.

Two varieties are used for dry land farming; California Feed barley, and the Bald. The Bald barley is one of the best drought resisters, but the straw is weak near the head and with a good yield much of the grain falls down. California Feed barley is the best yielding variety in seasons of good rainfall.

Oats is a poor dry land crop; very uncertain in yield. Many farmers sow oats, and if the drought is so severe at the time of heading that the heads will not fill, the crop when in bloom is cut for hay. The hay is excellent for horses and dairy cows. Kherson and Sixty Day are the varieties usually recommended.

Speltz, or Emmer, as it is correctly called, looks like a cross between barley and wheat. In threshing, the chaff remains attached to the grain. It is a strong drought resisting plant, and the grain is a good feed for horses, cattle and sheep. The grain contains too much hull to be a hog feed. Sow with a drill, the same time as for barley, using forty-five pounds of seed per acre.

Flax, so far as tested, has proved to be a good dry land crop when the rainfall reaches an average, and a total failure in years of severe drought. In Lincoln county, in 1907, in large fields, the yield on sod was nine bushels per acre, and on summer fallow, twenty-two bushels per acre. In the same locality, in 1908, much of the acreage was not worth harvesting.

It is one of the best crops for putting sod in mellow condition for the crop which follows it. It should be sown early as it needs abundant moisture to push the young plants. Sow with a drill using twenty pounds of seed per acre.

Flax straw is a good cattle feed as it contains some seeds and the oil in them is needed to balance the deficiency in fat found in most dry land crops.

Dwarf Essex Rape has been described as a cabbage that keeps growing, but never forms a head. It stands cold and drought well, if sown as early in the spring, as the ground can be worked. Late seeding is a total failure in dry years.

Sow in rows twenty-four inches apart, using three to five pounds of seed per acre. Cultivate frequently. It is the next best pasture to alfalfa for hog feed. The hogs should be turned on the field when the rape gets eight to ten inches high. It is best to divide the field into two lots and change the hogs from one to the other as they eat the crop down.

Potatoes, if given special attention, can be grown most seasons on dry land farms where the soil is not heavy. In 1908, in a section of Kiowa county that produced no marketable grain, a farmer grew one hundred bushels of potatoes per acre on two acres. The patch

was on high land at the foot of a slope where it received the storm water from over twenty acres of prairie. The land was plowed about twelve inches deep, and furrows arranged to catch the surface water from the land above. The soil was thoroughly pulverized before planting and repeatedly harrowed and cultivated. A farmer in Phillips county reports good yields for eight consecutive years. He harrowed and cultivated the potatoes at least twelve times each year, and his fields received the surface water from land above.

Potatoes on dry land require early spring planting, strong seed covered firmly with moist soil, and repeated cultivation. Early Ohio and Rose Seedlings are the varieties generally recommended.

When potato bugs are too numerous, Prof. C. P. Gillette, of the Colorado Experiment Station, recommends the mixing of one pound of Paris green with fifty pounds of flour. Place the mixture in a sack of cheesecloth and shake the sack over the vines when the leaves are damp.

Stock Melon is a large citron, with firm flesh, that keeps well into the winter if protected from freezing by straw or earth. It is a passable substitute for roots and furnishes a much needed winter succulent feed for cows, hogs and poultry. It withstands drought well and a moderate quantity should be grown by every Plains farmer. Plant and cultivate the same as for watermelons.

HAY CROPS.

Wheat, oats and *bald barley* cut when the seeds are in the milk and cured with as little exposure to the sun as possible make good hay for horses. *Fodder* from corn and kafir corn will take the place of hay for work horses, care being taken not to have it dusty when fed. Horses will stand heavy work such as breaking prairie, when fed grain and fodder, but fodder is disagreeable to handle in mangers.

Brome Grass (*Bromus inermis*) is the most satisfactory drought resisting grass that has been tested on the Plains, and is generally recommended by those who have given it a careful trial under dry land conditions.

Most of the seed on the market has been heated, and but a small per cent. will germinate. The writer has always sown twenty pounds per acre, and has never yet secured a good stand nor seen one from seeding made by others. Brome grass spreads from the roots, and if the stalks are not over one foot to eighteen inches apart when first seeded, the stand will thicken to a good sod in a few years.

Select low land which receives storm water from land above and have the soil deeply plowed, thoroughly pulverized and well settled before seeding, with a good supply of moisture stored in it. Seed with a drill. The seed is chaffy and is very difficult to sow, requiring two men, one to drive and one to see that the seed works down steadily.

Keep down the weeds and wait with patience until the stand

thickens to a good sod. Brome grass furnishes good hay until the sod gets too thick and then will stand heavy pasturing. It gives early and late pasture and is often dormant in midsummer.

Alfalfa should be tried on most farms on the Plains. Select a low spot or a place at the foot of a long slope where surface water from the rains can be carried to it by furrows. Do not plant on sod. Raise other crops until the sod is thoroughly subdued.

Plow the ground deeply. Thoroughly pulverize and pack it and do not seed until the soil is moist to a depth of seven to nine feet, if you have to wait two or three years. While waiting, work the soil often and collect in it all the moisture you can from land above.

Alfalfa will usually fail when sown in freshly plowed land. Plow deep but get the soil well settled before seeding. Sow with a grain drill, using twelve to fifteen pounds of seed as early in the spring as the danger from severe frosts is over. Use no nurse crop.

Use seed grown on dry land. Seed from irrigated land is certain to bring a total failure, and a great proportion of the failures in eastern Colorado have been assured from the start by the use of seed from irrigated fields.

Prof. W. M. Jardine, U. S. Department of Agriculture, told the writer that in Utah a dry land strain of alfalfa had been developed that with an average annual rainfall of eleven inches yielded an average of two tons of hay per acre. Seed grown under such arid conditions finds eastern Colorado most congenial.

When one year old, alfalfa should be harrowed early in the spring and again after each cutting.

When two years old, and every year thereafter, alfalfa should be thoroughly cultivated with a disc harrow set to cut two to three inches deep. The alfalfa should be disked early in the spring and after each cutting.

Alfalfa should be cut as soon as the first blooms appear. It will live many years longer than if left until in full bloom before cutting. Alfalfa must not be pastured so close as to have the crowns eaten off; when this is done, the plants die.

Usually when alfalfa is seeded on dry land for the first time, it dies out in three or four years. The land should then be plowed and planted to another crop that can be thoroughly cultivated. At the end of one year reseed to alfalfa, using the same methods as employed for the first seeding. The second seeding usually thrives for many years as the first sowing has prepared the land to a good depth for the easy growth of the second seeding.

Prof. P. K. Blinn, of the Colorado Experiment Station, has made a special study of alfalfa and has prepared the following statement for this bulletin:

RAISING ALFALFA FOR SEED IN DRY FARMING.

If a farmer on the dry plains has a well that will furnish just enough water for fifty head of stock, it would be absurd for him to

try to keep sixty or seventy-five head on the same supply of water; and it is equally ridiculous for him to attempt to crowd plants in soil where the moisture is limited.

Some plants may develop with less moisture than others, but alfalfa is not one of these plants; on the other hand, it is conceded by all western farmers that an abundance of moisture is the key to success in growing alfalfa for hay.

When it is well established, alfalfa will endure long droughts and still revive when water is applied; to that extent, it is adapted to "dry farming," and its deep rooting tendency may enable the crop to grow without irrigation, if the roots can penetrate the moist soil.

There are some localities on the Plains where the run-off from heavy showers could be collected and diverted by ditches upon soil suited to alfalfa. Often in a draw, where moisture from the surrounding prairie is inclined to center, good encouragement for seeding to alfalfa is offered.

The number of plants to the acre that can be maintained in the dry farming district has not been determined; but at Rocky Ford, Colo., in 1908, an alfalfa nursery plat, without irrigation for eleven previous months, produced at the rate of two and three-fifths tons per acre the first cutting; and then made a second growth, equally as good, that was left for seed. The plat had been seeded, in 1907, to Turkestan alfalfa, and thinned to single plants twenty inches apart each way. It received one irrigation and was thoroughly cultivated that year. In 1908 the growth was made from the moisture that was stored and conserved in the soil; but such phenomenal yields can hardly be expected without irrigation. In the favored spots, before mentioned, alfalfa can certainly be grown if once established and properly managed.

The growing of alfalfa seed offers great opportunities to the farmer on dry lands, because the fact has been well demonstrated that alfalfa yields seed best when the plant makes a slow, dwarfed growth, when it really lacks for moisture, but has enough to set and fill the seed.

Seed grown under dry conditions has more vigor and vitality than seed produced with an excess of moisture, and it is usually free from dodder and other noxious weeds, if the field has had any cultural care. There is a demand for dry land alfalfa seed that far exceeds the supply.

In establishing alfalfa for seed production, under dry conditions, it is recommended to sow in rows eighteen or twenty inches apart, with two or three pounds of good seed per acre. A thin, uniform stand is absolutely necessary, even to thinning, as in beet culture, but the stand can usually be regulated by the amount of seed sown.

It has been found that plants twenty inches apart will support each other and not lodge or lay on the ground, as in thicker or thinner stands. With a good stooling variety like the Turkestan, plants six

to twelve inches apart in the row are thick enough. If all the seed would germinate, one pound per acre would be ample, but it is difficult to sow a small quantity uniformly in the row, and for seed production, it might pay to space and thin the plants.

The row system is essential, as it permits inter-tillage to eradicate weeds, and to conserve the moisture, and also allows deep cultivation to absorb winter storms, affording an opportunity to furrow out the rows and direct or divert any surface water that may or may not be needed. It is the only system that will allow the tillage that is so essential in all dry farming.

The four-row beet cultivator, with its weeding knives and other attachments, is an ideal tool for cultivating the crop. A four-row drill, adapted to sowing alfalfa seed, is needed to complete the equipment, but the ordinary beet drill, with the addition of an alfalfa or grass seeder attachment, can be modified to suit the work.

The seed should be sown shallow, not over an inch deep, and good results have been secured with the common garden drill by marking out the ground with the rows gauged in sets of four, to correspond to the four-row cultivator.

Where there is an opportunity to use flood water for irrigation the field should be ditched in every other row, and the furrows logged out with a sled made of short logs, eight to ten inches in diameter, and from three to four feet long, spaced to fit two furrows, so that the water may run through as quickly as possible, for the alfalfa crop for seed will need only a small application of water. A short rush of water after a sudden shower can be delivered over considerable ground if the field is properly ditched.

IMPLEMENTS AND POWER.

The yield under average dry land conditions is low and a large acreage must be handled per man in order to make a living. This requires a number of heavy horses and implements of large capacity. A man with two horses will hardly average plowing two acres per day. The same man with five or six horses and a gang plow can plow an average of five or more acres a day. The returns from his labor are two and a half times greater with the larger equipment. Riding implements are always preferable because with them a man does not get so tired that he can not think.

A breaking plow for sod should have a mould board either solid or of rods. A disc plow does very poor work in sod.

The mould board plow is preferable for old ground, except when the soil is so dry that it plows up in clods. A disc plow will turn over land very dry and hard without making clods. Extra shares should be purchased with each plow, as sharp shares save power.

The lever smoothing harrow should be twenty-four feet wide, in four sections, with the coupling bars so arranged that two, three or four sections can be connected as desired. With five or six heavy horses on a 24-foot harrow, a man can till thirty to sixty acres a day.

A riding attachment adds little to the draft and much to the comfort of the man.

A disc harrow is essential. It should cut at least seven feet wide and be operated with four horses. The disc harrow can be used to pulverize sod; cultivate corn, milo maize and sorghum; put a mulch on alfalfa fields, on stubble fields after harvest, and on ground in the spring. It makes a fair sub surface packer when weighted and the disks are set straight.

A four-horse sub surface packer is the most economical.

A lister is needed for planting corn, milo maize and sorghum for grain. With three horses and a single lister, a man can plant an average of seven to eight acres daily.

The most economical grain drill sows either eleven or thirteen feet. It should have single discs and easily removable press wheels that are coupled in pairs, each pair working independently.

The two-horse corn cultivator should have both broad and narrow shovels. The one-horse cultivator should have at least nine reversible teeth and be narrowed and widened with a lever.

A home made float is very useful when land is cloddy. A wagon and hay rack, a mower and a two-horse hayrake and small tools are needed. The grain binder and corn harvester can usually be hired to advantage. One good fanning mill is sufficient to grade the seed for a neighborhood.

GRASSHOPPERS UPON THE PLAINS.

Grass hoppers are often a serious pest. When the native grasses become dry, a cultivated spot of green plants attracts them from every direction. Many failures have been due to this cause alone.

A large flock of turkeys affords a good protection. One turkey per acre for the entire farm where half is under cultivation, will save the crops. The birds are herded on the fields during the day time and shut up in a wolf-proof enclosure at night. In the fall they are closely confined while being fattened.

Prof. C. P. Gillette, of the Colorado Experiment Station, advises remedies in press bulletin 38. This may be had on request of the Director.

"One of the simplest and often a very effectual remedy is to grow plenty of chickens or turkeys to range over the infested grounds. Wherever coyotes abound, however, precautions must be taken to protect turkeys and chickens at night. Turkeys are very profitable, if raised with proper care, as they protect the crops from destruction, forage nearly their whole living, and sell at a high price in the fall or winter.

"Hopper 'dozers' or pans are also very successful where they can be used. Anyone wishing directions for making a good hopper pan should write the experiment station for a copy of Bulletin No. 112."

Bulletin 146 June, 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

RAISING HOGS IN COLORADO

[Information Bulletin]

BY

H. M. COTTRELL

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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RAISING HOGS IN COLORADO

H. M. COTTRELL

ADVANTAGES IN COLORADO FOR RAISING HOGS.

The feeds raised in Colorado for fattening animals are the feeds which produce the choicest flavor in meat that it is possible to secure. Delicious flavor is the marked characteristic of Colorado-fed meat, whether it be beef, mutton, pork, or poultry.

Barley is adapted to every tillable section of Colorado, with the possible exception of the Arkansas Valley. It yields well, is a cheap crop to produce, and barley-fed pork, because of its flavor, sells for the highest prices in every market in the world where it is offered.

Field peas is one of the best yielding and cheapest grown crops in the mountain valleys that have an altitude of 6,500 to 8,000 feet. The flavor of pea-fed pork is considered by many epicures to be richer and more toothsome than that produced from any other feed. Barley yields well in all pea-growing sections, giving the feeders the benefits from both grains. These high valleys cover a large area, one, the San Luis, having a tillable area as large as the State of Connecticut.

Alfalfa thrives on a large part of the cultivated area of the State. Hogs make cheap gains on both the pasture and the hay, and alfalfa gives a choice flavor to the meat.

Barley, milo maize and wheat are profitable hog feeds, and are the surest grain crops for the dry land farming of the plains. Usually in the dry land sections much more can be made from wheat by feeding it to hogs than by selling it for grain.

Pork can be produced cheaply with proper management in Colorado. Barley, under irrigation, costs less an acre to raise than corn in the Mississippi Valley states, and will produce more pork. From 500 to 1,000 pounds of gain can be put on hogs during the season from an acre of alfalfa pasture. It costs, including the rent of the land, from $3 to $6 an acre to raise field peas, and feeders estimate that an acre of good peas, when pastured off, will put 400 pounds of gain on hogs.

MARKET SUPPLY AND DEMAND.

Denver is the chief packing center of Colorado, and hogs have been received at the Denver Union Stock Yards as follows:

	1906	1907	1908
Hogs from all sources	192,720	241,393	280,228
Hogs from Colorado points	17,000	33,951	61,049
Received from Colorado	8.82%	14.06%	21.78%

The larger part of the hogs received at Denver come from

western Nebraska and western Kansas. Shipments of fresh pork are made every week throughout the year to Denver from Kansas City and Omaha, the average being two to three cars weekly. Experts in the meat business estimate that there are shipped annually from packing houses in the corn belt to Rocky Mountain territory and the Northwest, of which Denver is the gateway, pork and pork products worth from $12,000,000 to $16,000,000.

One hundred thousand hogs are needed each month in Denver territory to supply the demand for pork and pork products.

THE HOG THE COLORADO MARKET WANTS.

The Colorado packer wants a well-finished, fat, blocky hog weighing alive from 220 to 250 pounds. During the winter months there is a good, but limited demand for the city whole carcass trade, for well-finished hogs weighing alive from 150 to 175 pounds each.

Hogs weighing alive 220 to 250 pounds each, will supply cured hams weighing 16 to 18 pounds, and sides of bacon weighing 10 to 12 pounds each. These weights command a premium of 75 cents per hundred pounds above lighter hams and sides.

Well finished hogs, only, are wanted. The hog should be well fattened and rounded out, the flesh coming well down on the hocks, and the fat on the sides should be from 1 to 1½ inches thick. In a finished hog the flesh will be firm and hard to the touch, and the hair will be smooth and lustrous.

The flesh should be firm, the fat pure white, and the best consumers want a good proportion of lean.

Most of the Colorado hogs marketed in the past three years have been unfinished and too light in weight. A well finished hog will dress 80 per cent.; the average at the Denver packing houses in 1908 was 73 per cent.

The chief trouble has been that most Colorado farmers neglect their hogs through the summer, stunting them, and stunted hogs do not finish well. An unfinished, stunted hog weighing 150 pounds, will dress about 65 per cent. Bacon from such hogs sells at wholesale for one-half that from finished hogs. The bacon from the unfinished, light hogs, when cooked, consists of skin and flabby, soft meat, and the consumer is dissatisfied.

The flesh on the live, unfinished hog is soft and flabby to the touch, and the hair has a dead appearance. The meat from an unthrifty hog is always soft, and that from thin hogs is usually soft.

A common fault is uneven quality in a shipment, some hogs being of good weight and well fattened, and others small or thin. Unless the demand is pressing, a car load of mixed hogs will sell for the price which the poorest are worth.

Every defect in the form of the live hog, or in his condition, lowers the price of the marketable products from him, and brings a corresponding reduction in the price paid to the feeder. Every hog raiser should spend a day in the market with experts from the stock yards and packing houses, and learn to know how a choice hog appears and the feel of his flesh. The feeder should go to the packing houses and see the difference in the character of the cuts made from well fattened and from unfinished hogs.

THE BEST BREED OF HOGS FOR COLORADO.

The best breed is the breed that the grower likes best. There are more differences in the individuals of any breed than there are between choice animals of the different breeds. A good hog, well bred from a prolific strain of any of the popular breeds of hogs,

THE BERKSHIRE.
A Prize Winning Berkshire.*

will make money for the Colorado farmer when handled right.

There are four breeds that have been found to be particularly adapted to Colorado conditions: Berkshire, Duroc-Jersey, Poland-China, and Tamworth.

Whatever breed the feeder selects, he should stay with it, and not change or cross with another breed.

White hogs are generally not profitable in Colorado. The intense sunshine blisters and cracks their tender skins so that they become runts. Often this blistering is so severe that running sores are formed. A few Colorado farmers have made good profits from

*Owned by J. De Bon, Nashville, Tenn.

white hogs by keeping them in pastures having heavy shade.

The Berkshire is hardy and active, adapting itself to any condition suitable for raising hogs, and may be developed either into a bacon or a lard hog, according to the feed given.

It is more energetic than some of the other breeds, and on this account requires a better fence. Its activity makes it a good hog for pasturing and for following cattle in the feed lot, and this gives it a well developed muscular system that furnishes a good proportion of lean in the meat.

The Berkshire is a good feeder, matures early and may be fattened at almost any desirable age.

The sows are careful mothers and good sucklers. Originally

THE DUROC-JERSEY.
Prize Winning Duroc-Jersey.*

the Berkshire was very prolific, and many strains are productive today. Some families have been bred to concentrate the blood lines of prize-winning animals until they have become shy breeders, and in selecting animals for breeding, especial attention should be given to securing those with prolific ancestors on both sides. The Berkshire is strong in transmitting characteristics to the offspring.

The Berkshire is an attractive hog, black with white on face, feet and tip of tail. Its head, nose and legs are short, and for this reason the breed is a prime favorite with packers because of the small per cent. of waste from these cheap parts. The fat and lean are well distributed in the meat, making a high quality of pork.

The Duroc-Jersey is a typical lard hog of good length with a

*Owned by C. F. Burke, Rocky Ford, Colorado.

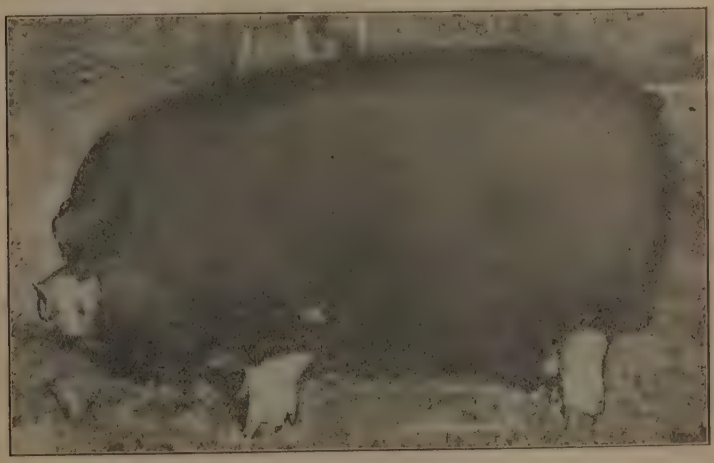
smooth, thick-meated body, built close to the ground. It is solid red in color.

It is an active, hardy hog, a good feeder and a good grazer. When well fed, it matures early, and if kept until full grown can be made very heavy.

The Duroc-Jersey is a prolific breed. Records taken from hundreds of sows by the U. S. Department of Agriculture show an average of nine pigs to the litter.

Mature sows can be handled in Colorado to have two litters a year, and the prolific character of the breed, together with its good feeding qualities, have made the Duroc-Jersey very popular.

The carcass often shows more bone than either the Berkshire or the Poland-China, and the meat is often not so fine grained.



THE POLAND-CHINA.
Prize Winning Poland-China.*

Duroc-Jerseys for breeding should have constitution and quality. Coarseness of bone and hair, particularly of the hair along the back, should be avoided. Hogs of this breed are inclined to have weak pasterns, and breeding animals should be selected that are strong in this respect.

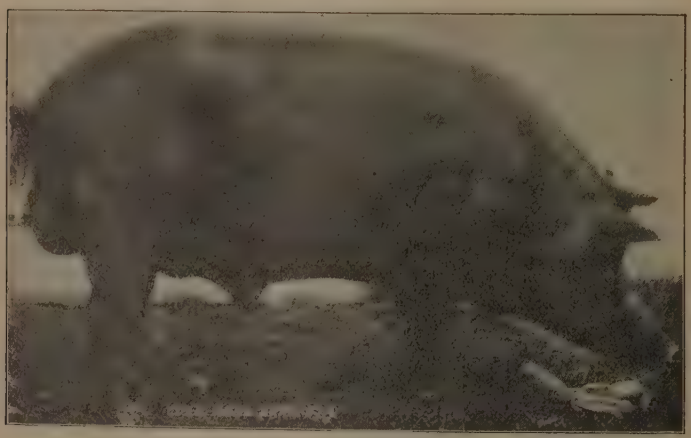
The Poland-China is an almost perfect meat making machine. It is not excelled by any breed of any kind of live stock for converting feed into flesh. It has a voracious appetite, a good digestion, and is lazy—not using much of its energy in travel or excitement. It will stand heavy feeding and considerable neglect.

*Owned by H. C. Dawson & Sons, Endicott, Nebraska.

When properly handled, it is ready for the market at any time after six months of age, whenever the price is right.

It is a typical lard hog, with a thick, short, massive body, fine quality of bone, hair and skin, small, fine head and short legs. It is thick fleshed with heavy shoulders and hams, and broad, thick loins. The meat is fine grained, but with too large a proportion of fat in the matured animal.

The chief fault with many strains of the Poland-China is that through over-feeding of corn they have become poor breeders, having only one to four pigs in a litter. Such pigs are usually choice feeders, but the number in a litter is too small to make it profitable to keep the sow.



THE TAMWORTH.

Champion at World's Fair—Tamworth, Weight 1,000 Pounds.*

Where sows are selected from prolific strains and fed muscle and bone-making feeds, they are as prolific as any breed. Three Poland-China sows on the Colorado Agricultural College farm had thirty-one live pigs at one farrowing. Records compiled by the U. S. Department of Agriculture of several thousand Poland-China sows showed an average of 7½ pigs to the litter.

The Tamworth is a strictly bacon hog with a smooth, long, deep, thin body, and looks to most people like a "razor back." It has been bred to produce as large a proportion of its weight as possible in an even thickness of choice bacon.

The two strongest characteristics of the Tamworth are lean

*Owned by W. Weaver Morton, Russellville, Tennessee.

meat and large litters. For three years on the Colorado Agricultural College farm the average for all sows was ten live pigs to a litter. A two-year-old sow weighing 750 pounds had 18 live pigs at one farrowing. Fully matured sows, well cared for, can produce two litters a year. A Tamworth sow at the Iowa Agricultural College raised 33 pigs in one year. The Tamworth is solid red in color, and is hardy and active—a good hog to keep on pasture.

The first cross with a pure bred Tamworth produces an easy feeding, rapid growing hog that is generally popular. The second cross is usually unsatisfactory, the pigs in the same litter frequently being of entirely different types, some chunky and others extremely lengthy, with an unpleasant variety in mixtures of colors.

Most Colorado stockmen who have tried the Tamworths do not like them. As a rule, Colorado stockmen neglect their hogs in summer when the field work crowds, planning to give them extra attention in the fall. With this treatment the Tamworth becomes stunted, and once stunted he can never be made profitable, and had better be killed. The surplus fat on the lard hog will carry him over a period of neglect—the Tamworth does not have the lard.

SELECTION OF THE INDIVIDUAL.

The selection of breed is a matter of fancy; the selection of the individual animals for the foundation of the herd is the basis for profit or losses.

The first consideration should be to get both boar and sows from prolific strains, and of the type demanded by the market. Except during the few weeks when the pigs are suckling, it costs as much to keep a sow that has one to four pigs in a litter, as it does to keep one that has eight to ten pigs. The first cost of the new born pig is determined by the cost of keeping the dam, divided by the number of pigs in the litter.

Uniformity in type is essential for the largest profits. No two breeds or types feed exactly alike, and where there is a mixture there is a variation in finish and weight that lowers the selling price. Both the boar and all the sows should be pure bred, of one breed, and of the same type. Miscellaneous crossing is a sure way to reduce the profits.

There are three serious defects to avoid in selecting animals for breeding stock: Weakness through the heart, weak or swayed back, and weak pasterns. These are faults which the swine growers of the corn belt have learned from years of costly experience to avoid, and no other good qualities will compensate for these defects.

Most of the Colorado stockmen have had but little recent experience with hogs, and look only for good development in ham and shoulder. Breeders in the corn belt have learned this, and ship to Colorado breeding stock that on account of light heart, sway back, or weak pasterns is unsalable at home.

With Berkshire, Duroc-Jersey and Poland-China hogs, the most valuable parts are the hams, back, sides and shoulder. The animal should have a back broad and arched, deep, thick-meated sides, and heavy ham and shoulders. The different parts of the body should blend smoothly into each other and be evenly covered with flesh.

In selecting Tamworths, the animals should be strongly of the bacon type; the body of great length between shoulder and ham, the sides deep, and the shoulders and hams light, uniting evenly with the body, so that a straight edge placed on the ham and shoulder will touch the side along its entire length.

HOW TO START WITH HOGS.

For capital, labor and time required, there is no business of any kind in Colorado that is paying larger profits than raising hogs where the grower is an expert. As high as 300 per cent. net profit has been made in six months under ordinary farm conditions.

The possibilities of so large profits have induced many farmers and business men who have had no experience with hogs to go into the business.

Many of these beginners with no knowledge have started on a large scale and have lost money. Handling hogs profitably requires skill and experience, and the beginner should start slowly and not get these at too great a cost.

Select any one of the four breeds you like best—Poland-China, Berkshire, Duroc-Jersey, or Tamworth.

Get a good judge of hogs to select for you from one to five sows, not more. Select good individuals that come from prolific strains on both sides.

The man who has had no experience with hogs should start with one choice brood sow. His herd will increase as fast as his ability to manage it.

With careful management, from 12 to 20 pigs should be raised each year from a prolific, mature sow.

The beginner should study his hogs closely, becoming acquainted intimately with their habits, their likes and dislikes, learning what they need and what is bad for them.

Cheapness in production is the first point to be mastered by the beginner. In his breeding he should work for large litters, early maturity and quality.

Starting with one sow, it will pay to buy a mature one that has shown that she will produce good pigs and raise eight to ten at a litter. She should have two litters a year.

Cheap shelter can be made with straw, sod or boards. The beginner can watch his small lot of hogs carefully, and learn how to make them grow rapidly at least expense.

If any trouble occurs it can usually be seen in a small lot of pigs before it is past curbing. When there is a loss it cannot be heavy and the grower gets his experience cheaply.

The second year three or four of the best sow pigs should be saved with their dams.

The third year the grower should have learned enough about growing hogs to be able to handle ten sows and their produce, and after that he should know enough to slowly increase his hog herd to the limit of his farm.

Cheap shelter and fences should be used until the profits from the hogs will pay for better ones. No large building should be erected until hogs have been grown several years on the farm and the breeder is sure of what he wants and where he needs to locate it.

Success in hog raising is determined by intelligent daily, sometimes hourly, care, attention to many small details, and good judgment. When a farmer decides to become a hog raiser, he should plan to stay permanently in the business. Just before the last panic hogs were high and farmers in many sections of the State invested in them. Prices dropped, and many new beginners sold out even the brood sows. In six months prices were again high.

FEED AND MANAGEMENT OF THE BOAR.

The boar is more than one-half the herd, so far as influence goes. Each year he may show his strength or weakness in a hundred or several hundred pigs, and it is most important that he should be of the right type and in great bodily vigor with such strongly bred ancestors behind him on both sides that he will with certainty produce pigs of uniformly profitable type, good feeders that will mature early.

No matter how superior an animal a cross-bred boar may be he cannot be depended upon to transmit his qualities to his pigs. There is a constant likelihood of the pigs inheriting the characters of their scrub ancestors, and no farmer can afford to use any but a pure bred sire.

The boar should be evenly balanced, good in every point. The custom of selecting a boar unusually strong where the sows are weak and perhaps weak where they are strong, is a dangerous one. The pigs can most easily inherit the weak characteristics of both parents.

The newly purchased boar should be brought to his new home

at least six or eight weeks before he is to be used and accustomed to his new surroundings.

As soon as he arrives, he should be thoroughly dipped or washed with some of the coal tar dips for destroying lice, and given the same treatment after ten days. For three weeks after arrival he should be kept at a safe distance from all other hogs on the farm; then, if found free from disease, he may be placed in quarters near them. Dipping and quarantine should be applied to every hog or pig that is brought to the farm, as it will often prevent serious losses from lice and disease that would otherwise be carried by the new purchase to the swine already on the farm.

The boar pig should be pushed with growing feeds, so that he will make a gain every day until he reaches full, mature weight. A mixture of any two or more of the following grains is good: Corn, barley, or milo maize, with wheat, peas, or shorts. A liberal supply of skim milk is especially good. He should have all the alfalfa he will eat every day, either pasture or hay. A small feed of roots or cooked potatoes is good. Stunting, even for a short time, will permanently injure his value. He should weigh 300 to 400 pounds when 12 months old.

After reaching full growth, the boar, when not in service, should be given bulky feeds that will keep him full, satisfied, and in good condition, but that will not put on fat. Alfalfa, roots, and a small daily ration of any kind of grain.

A few weeks before the beginning of the breeding season the grain feed should be gradually increased, giving a mixture the same as when he was growing, and the amount of roots and alfalfa should be slowly reduced. The animal should be put in perfect condition and good flesh, but not made fat. The best results are not secured from a sire that is either fat or thin.

During the breeding season the boar should have an abundance of food, using the same combination as recommended for him while growing, except that just sufficient succulent feeds (alfalfa and roots) should be given to keep his bowels in good condition. A full supply of succulent feeds at this time is likely to make him infertile.

A boar should not be used for much service until he is at least twelve months old. A fully matured boar produces the most vigorous pigs, other things being equal, and if properly fed and handled, may be profitably kept for several years. His tushes should be cut or knocked off as often as they show considerable size.

The boar should serve a sow but once, and two sows a day should be the limit for a mature boar, and then he should have a

day's rest after every second or third day. He should be used before being fed. Handled in this way, a mature boar is sufficient for fifty sows. Over service results in pigs that are dead, weak, or puny at birth.

The boar should have comfortable shelter at all times—dry and free from draughts. His surroundings should be kept free from vermin. Remember, that from a breeding standpoint, he is half the herd. He should have daily exercise to keep him healthy and muscular. A half-acre pasture will furnish this. He will keep better natured and be easier to handle if allowed to run with the barrows outside the breeding season. If allowed to run with the sows during the breeding season, he will weaken himself by over service. At other times there is danger that he will injure the sows.

Keeping him in close, dirty quarters, or allowing him to range over the farm and neighborhood half starved, are both sure ways of making him valueless. Too much attention is rarely given to the boar, and his health and comfort should be looked after every day throughout the year.

It pays to train a boar from his first service to the use of a breeding crate. With it, any size and weight of boar can be mated with any size and weight of sow without injury to either.

FEED AND MANAGEMENT OF THE SOW.

A large litter of heavy, vigorous pigs at weaning time is the foundation of profits. The sow should be selected and from birth should be fed and handled to produce such litters.

The sow pig intended for a breeder should be pushed for the first year and given feeds that will make rapid growth, but that will not fatten. Such feeds as milk, alfalfa pasture, or hay, and moderate quantities of grain, such as wheat, peas, barley, milo maize, and shorts. She should weigh from 300 to 375 pounds at 12 months of age when in thrifty condition, but not fat. Ample exercise every day is necessary for health and to develop muscles and lungs. If the sow has made a good growth, she may be bred to drop her first litter when she becomes twelve months of age. She should be in perfect health and in good flesh when bred. The gestation period for the sow is 112 days.

While pregnant, the sow should be given muscle and bone-making feeds that will develop in the unborn pigs size and strong vital organs. The same feeds are needed for this purpose that are required by pigs after weaning. When the sow has good alfalfa pasture, only a small quantity of grain is needed. The sow should be kept in good flesh, but not fat. A heavy condition of flesh is favorable if it is put on with muscle-making feeds and the

sow has been given ample exercise. Under feeding is extremely detrimental. The pigs from a half-starved sow are weak and undersized at birth, and are stunted while suckling from lack of sufficient milk.

Constipation in the sow while she is pregnant, or suckling, must be avoided. Pig eating is often caused by constipation. Laxative and bulky feeds, such as pasture or alfalfa hay, will prevent this trouble, and should form part of the daily ration. Exercise is necessary to keep the bowels in good condition. Small feeds of roots are good. Heavy feeding of roots is often the cause of weak or dead pigs at birth. Feeding frozen roots is likely to cause abortion. The pregnant sow should be fed, sheltered, exercised, and handled in such a way as to keep her in good flesh and health. Everything that facilitates this condition tends to secure pigs with greater vigor and more profitable as feeders.

A blow or a strain of any kind to the belly of the pregnant sow is likely to result in pigs dead at birth, or pigs born the wrong way, with the consequent injury to the sow, or her death. Sows had to step over a six-inch board in passing through an opening between their yard and pasture. There were many dead pigs at farrowing, and some of the sows died from trouble while giving birth. The ground next to a hog pen was eight inches lower than the floor, and the brood sows had to climb over this step—dead pigs and dead sows at farrowing time was the consequence. Potatoes were dug with a plow and the land left in ridges. Pregnant sows had to travel over these to get to a pea field. At farrowing time there were many dead pigs, and two sows died. A boar allowed to run with sows that are bred will frequently knock them around and bring the same trouble. Horses or cattle running in a lot with brood sows will often injure the sows the same way. Not over five to ten bred sows should be allowed to sleep together, as crowding in cold weather may result in losses at farrowing time. Pregnant sows should not be allowed to run with fattening hogs.

A breeding record should be kept, and two weeks before the pigs are expected the sow should be placed in a farrowing pen connected with a dry yard large enough to allow her to exercise. The feed should be somewhat reduced, without any sudden change, and her bowels kept loose. She should have dry, sunny shelter, free from draughts. The sow should be petted so that she will like to have her feeder handle her.

It is best to have the sows farrow at nearly the same time and then the owner can watch them day and night during farrowing time. There should be just enough bedding for comfort and dryness. Cut straw or chaff is best. Little pigs often get

tangled in deep straw and are either crushed by the sow or die from exposure. Give the sow as little attention as possible while she is farrowing, unless she must have assistance. In severe weather place the pigs as fast as they come in a basket in which a blanket is laid over a warm stone. Keep them well covered, and after all are born and have become warm and dry, take them to their mother and place each one at a teat. Then cover the mother and pigs. During the first forty-eight hours watch carefully, and if a pig strays from its mother, put it back against her body where it will be warm.

Give the sow all the water she wants for the first twenty-four hours after the pigs are born, but no grain. Take the chill off the water in cold weather. For three or four days after the first twenty-four hours, give plenty of water, but feed grain and milk sparingly. Then slowly increase until, when the pigs are three weeks old, the sow is having all the feed she will consume. Give the pigs exercise and sunshine from birth, but do not allow them to get damp nor to be exposed to the wind.

When the sow is given a warm, rich slop, or other milk-producing feeds just after her pigs are born, a strong milk flow is forced. The new-born pigs get too much and have diarrhoea, which often kills them. They cannot take all the milk, and the sow's udder becomes inflamed and caked. When the pigs suckle, the pain becomes so intense that in desperation she jumps up, kills, and eats them.

Overfeeding and lack of exercise cause the thumps in young pigs, but usually in Colorado, when pigs are thought to have the thumps, they actually have pneumonia, due either to damp beds or exposure to draughts.

Good sows improve for several years in the number and size of the pigs they have at a litter. The U. S. Department of Agriculture compiled the records of over six thousand sows and found yearling sows averaged 6.65 pigs per litter, and five-year-old sows averaged 8.4 pigs per litter. At the Wisconsin Experiment Station year-old sows averaged 7.8 pigs per litter, with an average weight per litter of 14.2 pounds, while sows from four to five years old averaged 9 pigs per litter with an average weight per litter of 26 pounds. The common practice of farmers selling their old brood sows each year and reserving immature ones for breeding is a bad practice, as the older sows are much better mothers and their pigs have a strong advantage in greater vitality at the start.

The beginner had better arrange to have the pigs born in May, when the sows can be turned on pasture soon after farrowing. Most experienced Colorado hog raisers do not want pigs

to come in March or in the first half of April on account of storms and winds. February is a good month for farrowing. The weather may be cold, but there is usually little wind and the yards are not muddy.

The period of gestation is 112 days, and the sow may be bred three days after the pigs are weaned. When mature sows are to have two litters a year, the sow, if bred October 12th, will farrow about February 1st. Allowing the pigs to suckle nine weeks, they will be weaned about April 4th, and the sow bred the second time three days later. The second litter will then be born about July 28th, and if suckled ten weeks, will be ready to wean about October 7th.

FEED AND MANAGEMENT OF THE GROWING PIG.

Pigs should not be weaned until they are at least eight weeks old, and if the sow is not to have a second litter, or if there is time enough in case she is, it is better to let the pigs suckle until they are ten or twelve weeks old. Farmers often get in a hurry and wean pigs when six weeks old; but unless there is an abundant supply of milk, and especially good care is given, the pigs are likely to become stunted, sometimes so severely that they never recover.

The cheapest way to put gains on young pigs is through the sow. She has a strong digestion and can turn coarse grains and pasture into easily digested milk.

The sow should be fed to produce a high yield of milk, and the pigs should be kept with her until they get to eating a full feed of both grain and pasture.

Pigs will begin to nibble at feed when they are about three weeks old. At this age they should be given a little milk in a trough separate from the mother. After they get to drinking the milk freely, add a little soaked whole grain—barley, wheat, peas, milo maize, or corn. Do not give more than they will eat up clean at one time, and clean the trough well before each feeding.

The boars should be castrated before being weaned.

When the time comes to wean the pigs, cut down the sow's ration to water and alfalfa hay. She will dry up without injuring her udder. When she is giving a large supply of milk and all the pigs are taken away at once, her udder is often ruined and she becomes unable to suckle another litter.

When first weaned, feed the pigs from three to five times a day. While with their mother, they took their meals at least every two hours, and too sudden a change is detrimental. After they get to growing vigorously, cut down to two meals a day, and when they weigh 75 pounds each and are on good pasture, feed once a day, and that at night.

When first weaned, feed the pigs some skim milk, if possible. It makes the change from mother's milk easier. Whole milk is good, but as butter fat is worth $400 to $960 a ton, it is expensive pig feed. Tankage will take the place of milk, when made about one-fifth the total weight of the grain fed.

A variety of feeds will give larger and cheaper gains than will any single feed. Peas, barley, wheat, rye, milo maize, and corn are the grains to use in Colorado. Soak from 24 to 48 hours, each time, feeding a mixture of at least two grains.

Do not sour the feed, and keep the troughs, pails, and barrels used in feeding sweet and clean.

Half the weight of a two-hundred pound pig should be made from pasture. Alfalfa makes the best pasture, followed by rape, clover, and a mixture of wheat, oats, and barley sown thickly.

A pig should be fed some grain every day. After he gets to growing well, a small quantity of grain is sufficient, but it is never profitable to keep a growing pig on pasture alone and without grain. The pig should make a regular daily gain from birth to fattening without a check of any kind. The growth should be made with the least possible daily feed of grain and the largest profitable amount of forage. Careful daily attention can only determine what these amounts should be.

Pigs need fresh, clean water always before them. If a well is not convenient, the water can be supplied cheaply in barrels to which are attached hog waterers. Do not water directly from a stream. It often carries disease.

They must have warm, dry, clean shelter, free from draught, every night in the year, and they need a shade from the midday sun.

FINISHING FOR THE MARKET.

From 60 to 75 days before the pig is to be marketed he should be confined in limited quarters and fed heavily on grain until he becomes well finished and fattened. Up to this time he should be kept growing every day, but fed as little grain and as much forage as can be done and maintain a thrifty growth, and he should be given ample exercise.

Fattening hogs will make the greatest gains when they have just enough exercise to keep their appetites sharp. A fattening hog should be limited to half an acre, and 25 fattening hogs kept on this area will do better than a greater number. The hogs should be sorted to lots of even size and age, and no matter how many are being fattened, not over 25 should be allowed to run together. Brood sows should not be kept with fattening hogs.

The hogs should be fed at regular hours, either two or three

times a day, and at each feed should be given just a trifle less than they will eat up clean. The profits come from inducing the hog to consume a large quantity of grain and maintain a sharp appetite. The feeder will secure the best results by watching the hogs each time until they finish eating. He will then know whether the hogs are slow about cleaning up the feed, showing over feeding, or whether they clean up the feed quickly and need more.

The hogs should have all the clean, pure water they will drink at least three times a day. Colorado feeds are rich in protein, and a hog eating them needs much more water than when eating corn.

The hog should, before being marketed, be well fattened, smooth and well rounded with a good outer covering of fat, and be firm and solid to the touch. If the feeder will go into a pen of thin hogs and feel them along the loin and back, and then into a pen of well fattened hogs, he can quickly learn the "feel" that indicates a good finish. The hogs should be sorted to an even size and weight before being shipped.

FEEDING HOGS AT THE COLORADO EXPERIMENT STATION.

The results obtained from seven feeding experiments with hogs have been published.

Colorado Experiment Station Bulletin 40. W. W. Cooke.

1894 '95	Pounds Feed Required for 100 lbs Gain	Gain Per Pig Pounds
California Feed Barley	540	88
Corn	560	76
California Feed Barley	430	105
Corn	430	113

1896 '97	Pounds Feed Required for 100 Pounds Gain	
	Grain	Skim Milk
Whole Corn	700	110
Ground Corn	540	110
Whole Bald Barley	500	130
Ground Bald Barley	360	80
Whole California Feed Barley	540	70
Ground California Feed Barley	430	110
Ground Corn and Feed Barley	410	80

Professor Cooke concluded that one-half more ground corn was required to make a pound of growth than when ground barley

was fed, and that feeding corn and barley together produced a quarter more growth on a fifth less feed than feeding the two grains separately. Ground bald barley was one-half better than whole bald barley. Ground feed barley was one-twelfth better than whole feed barley, and ground corn was one-fifth better than whole corn.

Colorado Experiment Station Bulletin 74. B. C. Buffum, C. J. Griffith:

1900 1901	Pounds Feed Required for 100 lbs. Gain	Gain Per Head Pounds	Dressed Meat Per Cent	
Corn ⅔ Barley ⅓	544	110	86 1	Pigs at start weighed 150 to 160 pounds each. They ate a little more than ½ pound of hay per head per day. Hay chopped and mixed with slop. Pigs ate about one pound of beets per head daily.
Alfalfa Hay	49			
Corn ⅔ Barley ⅓	528	105	87.4	
Corn ⅔ Barley ⅓	555	96.4	87.1	
Sugar Beets	103			
Second Test				
Corn	643	65.5	78.6	
Wheat Oats Barley ½	487	85.6	79.2 79.2	
Corn ½ Shorts ½ Corn ½	609	73	77.4	
1902				
Sugar Beets chopped in small pieces	6130	16.75	77	Pigs 100 pounds each at start.
Ground Wheat and Barley equal parts	450	120.25	84	
Corn, shelled	540	71 25	88	
Ground Wheat and Barley equal parts	420			
Sugar Beets	400	.98	84	

Prof Buffum concluded that sugar beets were unprofitable, either alone or in combination with grain. Pigs weighing 100 pounds each, fed 99 days all the sugar beets they would eat, and no other feed, made an average gain per head of 16.75 pounds. It required 61.3 pounds of beets to make one pound of gain, one ton of beets producing 32.6 pounds gain. Where sugar beets were fed with wheat and barley, one ton of beets took the place of 150 pounds of the mixed grain. With a mixture of ground wheat and barley worth $1.00 per 100 pounds, corn was worth 83.3 cents per 100 pounds. The grain showed a greater feeding value than that grown in the humid section.

Colorado Agricultural College, "News Notes." G. E. Morton:

	Pounds Feed Required for 100 Pounds Gain.				Gain Per Head Lbs. 12 Weeks
	Grain	Hay	Tankage	Sugar Beets	
Barley / Alfalfa Hay	469.4	59.8			109.3
Corn / Alfalfa Hay	556.0	74.1			99.1
Barley / Sugar Beets	483.9			469.9	88.9
Corn, Sugar Beets	591.7			518.6	76.7
Barley ½ / Corn ½					
Alfalfa Hay	450 3	61.4			119.5
Barley ½ / Wheat ½	499.6				103.6
Barley ½ / Peas ½	513 3				98.7
Barley ½ / Shorts ½	476.1				106.1
Barley 9 10 / Tankage 1 10	417.4		47.2		120.1
Corn 9 10 / Tankage 1 10	394.1		42.8		132.5

The pigs averaged 80 pounds each at the start.

Professor Morton concludes: To sum the matter up, corn and tankage make a very cheap and satisfactory ration, producing the largest gains of any ration used. Barley and tankage makes a cheaper ration than barley and wheat, or barley and peas, but not quite so cheap as barley and shorts, although producing the second largest gains. Barley, corn and alfalfa hay proved a very satisfactory ration, being second only to corn and tankage in cheapness, and producing the third largest gains of any ration. The corn and alfalfa hay ration did not prove satisfactory, being the costliest ration used, with the exception of the beet rations. The beet rations were not in the running.

The amount of feed required for one hundred pounds of gain is given, so that one can figure the cost with the prices that prevail in his community.

Dry alfalfa hay was fed in racks, and comparing barley and alfalfa hay with barley and wheat, barley and peas, and barley and shorts; one ton of alfalfa hay had a feeding equivalent of 233 pounds of shorts, 1,000 pounds of peas and 1,467 pounds of wheat.

COLORADO HOG FEEDS.

Field Peas.—The chief pea feeding section in Colorado is the San Luis Valley, where the altitude is from 7,500 to 8,000 feet.

Field peas are seeded on unplowed ground in fields of 40 to 320 acres. No further attention is given except to irrigate once or twice. The vines grow and bloom, and the pods fill until killed in the fall by frost, when they cure on the ground without being cut. Hogs are turned into the field, gather the crops, and when fat are shipped to market.

It costs, including the rent of the land, from $3 to $6 an acre to raise peas, and feeders estimate an acre of good peas will put 400 pounds of gain on hogs when pastured off.

Sometimes the peas are harvested and stacked, and the unthreshed vines fed from the stack to hogs confined in yards. An acre of good peas fed in this way will put from 600 to 800 pounds of gain on hogs.

A new method of harvesting field peas at a low cost has been lately developed. The frosted vines are left on the field until they become well cured, and are then gathered without being cut, with the bull rakes used in haying. Some vines are left where the bull rake is started in, but as soon as a full forkful gathers on the rake, the vines are taken up clean without shelling; when a load is gathered, the rake is driven to the stack and the vines placed on the stack with an ordinary hay stacker. Three teams and five men with this method, can gather and stack 20 acres a day at a cost not to exceed $1 an acre.

The pork from hogs well fattened on peas is firm, sweet and tender, and has a most delicious flavor. The following figures show the actual cost per acre to a grower in the San Luis Valley:

Seeding	$ .35
Seed, 60 pounds at $1.75	1.05
Labor irrigating	.25
Water rent	.08
Rent of land	3.00
	$4.73

The crop was gathered and stacked, and the unthreshed vines fed to fattening hogs confined in a small lot. The hogs made a gain of over 700 pounds for each acre of peas consumed.

Hogs fed peas alone fatten unevenly, some finishing quickly, while others gain, but become unthrifty, showing that a diet of this one grain does not agree with them. Denver packers report that one-half the pea-fed hogs marketed from the San Luis Valley in 1908 were in an unfinished condition.

There are three reasons for this: Peas is a concentrated feed, rich in protein, and feeding them alone to hogs is like giving a man beefsteak only. Where the leaves are eaten with the grain, they help dilute the feed, and it is profitable to feed barley or wheat

once a day. A few trials indicate that a light daily feed of potatoes or roots is beneficial for hogs fattening on peas.

Hogs drink a much greater quantity of water when eating peas than they do when given a starchy feed like corn. When hogs are confined in a small lot, and the peas are fed close to a trough of water ,they will take a drink of water between every mouthful or two of peas. When turned into large pea fields to fatten, hogs often have to travel from one-fourth to three-fourths of a mile to water and they wait too long between drinks. Most hogs will travel too much in a large field to finish well.

The peas are often stacked and the unthreshed vines fed through the summer to breeding stock and growing pigs. Sows on this feed give milk abundantly, but become very thin.

The quality of the pork and the cheapness of its production merit a wide development in pea feeding. San Luis Valley has a tillable area equal to the entire state of Connecticut, and if one-half this tillable area was devoted to hog raising, there could each year be marketed from the valley over three million well fattened hogs. The area of land in Colorado adapted to pea growing outside of the Valley is probably greater than that in the Valley.

Field peas thrive in Colorado at an altitude of 6,500 to 8,000 feet. They have, so far, not proved to be a profitable crop at lower elevations. Mr. J. H. Empson, Longmont, who raises hundreds of acres of peas for canning each year, and has made a careful study for 20 years of pea growing, stated to the writer that he believed that field peas would be a profitable crop on irrigated land at an altitude of 5,000 feet, if they were seeded in February. Later seeding would certainly fail.

Barley is adapted to every tillable section of the State, except possibly the Arkansas Valley. The feed and malting varieties of barley yield well in irrigated sections having an altitude of from 5,000 to 7,500 or 8,000 feet, and bald barley is adapted to the plains and to high altitudes. The yield of barley in the irrigated sections will produce more pork per acre than will the average yield of corn in the corn belt. Barley is produced at less cost per acre in the irrigated sections of Colorado than corn in the Mississippi Valley.

The English market is the most critical in the world for bacon, and Denmark sells to England each year bacon from barley-fed hogs to the value of over eighteen million dollars. Danish bacon from barley-fed hogs sells on the English market for an average of 46 per cent. above the average of the American bacon from corn-fed hogs. The high yield of barley, the cheapness of its production, its adaptability to all sections of the State, and the superior quality of the pork made from feeding it, should make Colorado a

great hog raising state.

Barley feeding produces fine pork with choice flavor and a white fat—the three qualities demanded for the highest priced pork products.

The feed and bald barley are not as appetizing as corn, and hogs grow tired of them. It is, therefore, best to feed the barley in combination with some other feed or feeds. Alfalfa, peas and wheat maintain the appetite well. The Danish and Canadian feeders generally use skim milk or buttermilk, and both of these dairy products improve the quality of the meat.

Wheat tests made at many experiment stations show that pound for pound, wheat is equal to corn for making gains on fattening hogs. Professor Buffum found, at the Colorado Experiment Station, that a mixture of equal weights of wheat and barley was worth 17 per cent. more than corn for fattening hogs.

Wheat is largely used for fattening hogs in Western Colorado and on the Plains, and the pork from it is likely to be tough and to waste unduly in cooking. Part of this is probably on account of many wheat-fattened hogs not being well finished. The fat has a dingy color. Often the price of wheat, or the distance to market make it much more profitable to feed it to hogs than to sell it as grain. In such cases the hogs should be fed for 60 to 75 days with barley, field peas, or corn, as these feeds whiten the fat and improve the flavor and texture of the meat.

Wheat Bran.—This feed contains too much woody fibre to be a profitable feed for either growing pigs or fattening hogs. It is sometimes useful to feed to mature breeding animals, when bulk, with a moderate amount of nutrition is wanted, and may be used as a laxative feed just before farrowing. The leaves of alfalfa hay have every good quality of bran as a hog feed, are more nutritious and much cheaper.

Wheat Shorts and Middlings are especially good feed for suckling sows and young pigs, and for fattening purposes are worth about 8 per cent. more than an equal weight of corn.

Oats.—The meat of the oat is excellent hog feed. The hull has about the same value as straw. Usually the high price and the per cent. of husk make it unprofitable to feed oats to fattening hogs.

When oats are fed to hogs they should be ground, and for young pigs the hulls should be sifted out. Oats whiten the fat and give a good flavor to the meat, and can sometimes be used with profit as part of the ration in finishing hogs fattened on wheat or rye. A mixture of equal parts, by weight, of ground wheat and oats, make an excellent ration for growing pigs.

Emmer, usually called speltz, is a drought resisting grain crop, and is a good feed for horses, cattle and sheep, but a poor hog feed, as it has too much husk.

Milo Maize is one of the best drought resisting crops, and is well adapted as a grain crop for hog raising for the Plains. It should be either ground or soaked. One hundred pounds of milo maize is equal to ninety pounds of corn for fattening hogs. The average amount of pork that can be produced an acre per year is much greater under dry land farming with milo maize than with corn. Milo maize is constipating, and some laxative feed should be given with it, such as alfalfa hay, flax seed, in small quantities, sorghum fodder cured green, tankage or bran.

Rye makes a good feed for growing hogs. It has the same defects as wheat and should be prepared and used in the same way as wheat.

Tankage consists of the scraps and trimmings of meat and bone from the packing houses, cooked, the fat removed and the residue dried and ground. It is rich in protein and in mineral matter, and should be fed in small quantities mixed with grain. It is of special value when fed with starchy grains, such as barley, corn and milo maize, and when fed with these grains in the ratio of 95 pounds of grain to 5 pounds of tankage, will reduce the amount of feed required to make 100 pounds of increase in live weight from 20 to 35 per cent. Tankage-fed hogs finish well, the flesh is fine and the hair and skin thrifty.

Tankage is the best substitute for skim milk for feeding pigs just weaned, and should form one-fifth of the total weight of grain fed for a short period, and then one-tenth, until they get to eating alfalfa well.

Skim Milk.—No other feed is equal to milk for feeding pigs just weaned. It makes the change from mother's milk easier. Whole milk is good, but as butter fat in Colorado is worth from $400 to $960 a ton, it is expensive pig feed. Skim milk should be fed sweet and mixed with the grain. It has the greatest value when not over three pounds of milk are fed for each pound of grain, and when fed in this ratio, from 325 to 475 pounds of skim milk have a feeding value equal to 100 pounds of grain for feeding hogs.

Skim milk is a valuable feed for fattening hogs, and it improves the quality of the flesh. The high quality of both Canadian and Danish bacon is undoubtedly due, in considerable measure, to the feeding of skim milk or buttermilk to hogs throughout their lives. Milk is an easily digested feed, it aids in the digestion of the grain fed with it; it is appetizing and healthful, and fed to the growing pig promotes development of muscle and bone.

Buttermilk, fresh untainted, and not diluted or over salted, has a feeding value equal to skim milk.

Sugar Beets.—In experiments made at different times by Professor Buffum and Professor Morton, at the Colorado Experiment Station, it was found unprofitable to feed sugar beets to hogs.

Professor Buffum concluded that sugar beets were unprofitable either alone or in combination with grain. Fed alone, one ton of sugar beets were required to produce 32.6 pounds of gain, and when sugar beets were fed with wheat and barley, one ton of beets took the place of 150 pounds of grain.

Professor Morton reported that when sugar beets were fed with grain to fattening hogs, they proved wholly unsatisfactory.

At the Experiment Stations of Montana and Utah, sugar beets fed in small quantities with grain to fattening hogs were found to be valuable.

Professor Day, of Ontario, made many experiments in feeding roots, and found that in feeding roots with grain to fattening pigs, one ton of sugar beets was equal to from 250 to 330 pounds of mixed grain. He obtained the best results by feeding equal parts by weight of beets and meal. The influence on the firmness of bacon was very favorable.

Potatoes.—No tests have been made of feeding potatoes to fattening hogs at the Colorado Experiment Station. Several other stations have tried them, and it has been found that potatoes alone do not make a satisfactory feed, and that raw potatoes have little feeding value. Potatoes cooked until dry and mealy and mixed with raw grain make a palatable feed, and from 400 to 450 pounds of potatoes are equal to 100 pounds of grain.

Apples.—There are a good many cull apples available for feeding hogs in the fruit sections of Colorado. Three tests of feeding apples with grain were made at the Utah Experiment Station. In one, apples were of no value; in the second, 25 pounds of apples were required to make one pound of gain; and in the third test, apples were equal to grass pasture.

Squash.—In some sections of Colorado stockmen fatten hogs exclusively on squashes, feeding them raw. They report profitable returns per acre with meat of good flavor, but with an objectionable yellow color. We have been unable to secure any data upon the pounds of pork made per acre of squash.

Gleanings.—Many Colorado farmers have found it profitable to put a hog fence around their farms. After the crops are harvested, the hogs are given the run of the farm. They pick up the scattered grain in the stubble fields, graze on the alfalfa, and eat what beets and beet tops they want. Hogs given good shelter thrive well under these conditions, and often several hundred dol-

lars' worth of pork is made from feed that would otherwise be wasted.

PASTURE FOR HOGS.

Grain is high priced in Colorado, and at least half the weight of a 200-pound hog should be made from forage. Raising a hog without pasture in Colorado usually is a losing business. At the same time, a growing pig should have some grain every day, no matter how good the pasture. Sometimes it is profitable to keep dry, mature sows on pasture alone, but it may be taken as a general rule that every hog should have some grain every day of his life.

The feeder should keep a close daily watch on his growing pigs and keep them steadily gaining in weight, using the least amount of grain and the largest amount of pasture that can be done and secure a regular, good growth.

No matter what the size of the pasture, it is best to divide it into at least two lots and change from one to the other as the hogs eat the feed down. Hogs do not thrive best on soiled pasture, and do better when changed often enough to keep the feed clean.

Rings may be put in the hog's noses to prevent them from rooting, but if the pasture is sufficiently large and some grain is fed daily, the hogs will do little damage from rooting and are better off for it.

Alfalfa makes the best hog pasture. It is best not to pasture it until the second or third years of growth, and in Colorado alfalfa will usually furnish good feed from April 20th to Christmas, and sometimes later.

When hogs are fed some grain daily, they will make from 500 to 1,000 pounds of gain during the pasture season from an acre of good alfalfa after deducting the gain which the grain will make if fed alone.

An acre of alfalfa pasture is sufficient for from five to twenty pigs, depending on their size, the richness of the land, the season, and the amount of water available for the growth of the plants. It does not pay to pasture too close, and a good plan is to allow an acre of alfalfa for each sow and her pigs, and cut for hay what they leave.

Dwarf Essex Rape is next in value to alfalfa for hog pasture. It is similar in appearance to cabbage that does not head. It is a rapid grower, starts up again quickly after being pastured down, and will withstand severe frosts. It does well under dry land farming if seeded so early that it becomes well developed before drought and hot winds come. The writer has found it green and thrifty in the

San Luis Valley in November under eight inches of snow.

Rape is an annual, and can be sown as early in the spring as oats. It may be sown at any time from March to September. When planted in rows two feet apart and cultivated, from three to five pounds of seed are required per acre. Sown broadcast and irrigated, from five to six pounds of seed are needed per acre. Oats, or a mixture of oats, wheat and barley, may be drilled in deeply and rape sown broadcast afterward and covered lightly.

Hogs should be turned on rape when it is from eight to ten inches high. If the hogs do not keep the rape eaten down, it should be clipped with a mower occasionally. Where hogs run in tall rape it is likely to make sores on their backs.

At the Wisconsin Experiment Station, where shotes were fed grain and pastured on Dwarf Essex Rape, one acre of rape was equivalent to 2,600 pounds of grain.

Grain Pasture.—In the San Luis Valley and on the plains grain is often sown for hog pasture, using double the amount of seed necessary for a crop of grain. Rye is hardy, makes the earliest pasture, but soon becomes tough and bitter. Winter wheat pasture lasts longer than rye pasture. Good results have been obtained by sowing in the spring, a mixture of winter wheat, oats and barley, and reseeding once or twice during the summer.

Sorghum, sown in narrow rows and thoroughly cultivated until a foot high makes a good hog pasture in the dry land section of the Plains.

Sweet Clover makes a good hog pasture on dry lands and on alkali land in irrigated sections. Especially good profits have been made pasturing hogs on sweet clover with a little grain on alkalied land in the San Luis Valley.

HAY FOR HOGS.

Alfalfa Hay.—A Colorado hog should have alfalfa every day in the year. When pasture is not available, the hog should have bright, early cut alfalfa hay. At the Kansas Experiment Station the writer fattened one lot of hogs on all the grain they would eat, and another lot on all the grain and all the dry alfalfa hay they would eat. The alfalfa was cut early and was fed just as it came from the stack, forkfuls of whole hay being thrown in shallow troughs, the pigs being allowed to eat the leaves, and the waste stems being thrown out. The hogs on grain alone gained 524 pounds, while the hogs fed grain and hay gained 909 pounds. One ton of alfalfa hay took the place of 868 pounds of grain.

Professor G. E. Morton reported a test made at the Colorado Experiment Station in which one ton of alfalfa hay had a feeding equivalent of 233 pounds of shorts, of 1,000 pounds of peas, and

of 1,467 of wheat. Of course, alfalfa hay does not in itself have any such great feed value, but the hog eating alfalfa hay digests a greater proportion of the grain eaten.

The leaves only, are of value, the stems being too woody, and the hogs should be fed a sufficient quantity so that they will get all they want when they have eaten the leaves. For this reason it does not pay to cut or grind alfalfa hay for hogs, as these methods compel the hog to eat the indigestible stems. In a test made by the writer, hogs fed whole alfalfa hay ate 515 pounds of grain for each 100 pounds of gain, while those fed finely cut alfalfa hay required 538 pounds of grain for each 100 pounds of gain.

Alfalfa for hay for hogs should be cut when the first few blooms appear, cured with as little exposure to the sun as possible, and handled in such a way as to preserve the leaves. In feeding tests made by the writer with hogs fattened on grain and alfalfa hay, a ton of early, green-cured alfalfa hay was equivalent to 868 pounds of grain, and a ton of alfalfa hay cut late was equivalent to 333 pounds of grain.

Pea Hay.—In the San Luis Valley peas are harvested and stacked after the vines are killed by frost. The unthreshed vines are fed to brood sows and growing pigs through the summer. It is an advantage to feed the vines with the peas, and as in the case of alfalfa hay, the pigs should be fed enough so that they will eat the leaves only.

Sorghum Hay.—On the Plains, sorghum is thickly planted in rows, cut when the seeds are in the milk, and cured in large cocks. The green hay made by this method is a valuable feed to give in winter with grain.

WATER FOR HOGS.

Most Colorado hog feeds are rich in protein, and animals eating such feeds need a much larger amount of water than hogs fed on starchy feeds like corn. It is usually best to mix ground grain with water to make a thick slop, but no matter how much slop is fed, hogs should have easy access at all times to clean, pure water, separate from the feed.

It is dangerous to let hogs have access to irrigation ditches or streams, as these are great carriers of disease. A convenient way to water hogs is to mount a barrel on a small sled and attach a hog waterer. As many barrels and sleds can be used as are needed to maintain a full supply of water, and by this method the water can be placed in the pasture or feed lot where the hogs can reach it without travel. A hog should drink small quantities of water often, and not overload the digestive tract with large quantities, as he will when he has to travel a considerable distance for it.

PREPARATION OF FEED.

Grinding and Rolling.—The dry climate and intense sunshine in Colorado make the grain much harder and more flinty than those grown in the humid region. It is, therefore, usually not profitable to feed dry, whole grain. Rolling is preferable to grinding, and requires less power. Rolled grain is left in the form of flakes, while in grinding hard grains like Colorado barley, the ground particles of grain have sharp edges that are objectional. At the Colorado Experiment Station, Professor Cooke reported that ground bald barley was one-half better than whole bald barley; that ground feed barley was one-twelfth better than whole feed barley, and that ground corn was one-fifth better than whole corn.

Soaking.—The general experience of swine feeders in Colorado is that soaking grain from 24 to 48 hours has the same beneficial effect as grinding, at less cost, but with more trouble. Care must be taken in hot weather not to let the soaking grain sour, and in cold weather to keep it from freezing until eaten.

Cooking grain reduces its feed value. It has been found necessary to cook potatoes where any considerable quantity has been fed to hogs, and several feeders report good results from cooking sugar beets thoroughly, and then mixing the grain with the beets while they are still hot, but after the fire has been removed.

LICE ON HOGS.

Whenever a pig has good feed and surroundings and is not thriving, look for lice. Vermin will usually be found to be the cause of the lack of thrift. A great many of the losses laid to cholera, worms and mysterious diseases are actually the work of lice.

A stockman new in the hog business, bought several sows. He built good shelter and gave them good feed and care. They had 150 pigs, and all of these but 12 died before weaning time. After 138 had died, a veterinarian was called in to find what disease was killing the pigs, and he found that they had all been killed by lice. They were covered with vermin.

The writer inspected a herd of 300 hogs running on an alfalfa field and fed grain. They had a greyhound appearance, with rough hair, and were not over half so heavy as they should have been. After looking them over, the writer said that lice were stunting the hogs. The owner insisted that there was not a single louse on the whole herd. Several hogs were caught and were found to be very lousy.

The best cure and preventive is regular dipping, using some of the coal tar dips so extensively advertised and sold, or crude oil. When pigs are found to be lousy, dip twice, ten days apart,

and then once a month through the year. Dipping with coal tar dips not only kills the vermin, but keeps the skin and hair in a healthful condition and is worth the cost of the operation, aside from killing the lice.

The most convenient method is to sink a galvanized iron vat, the top level with the ground, and leave a shute leading from the hog lot to the vat, and another from the dripping board to the lot.

The dipping mixture can be kept in the vat all the time and be protected by a cover when hogs are not being dipped. With such an arrangement, it is a short and easy job to dip 50 to 200 hogs. The dipping mixture will need to be changed three or four times a year.

In Colorado it is safe to dip in winter if done on a warm, sunny day, and the hogs are kept in the sun and out of the wind until dry.

Where only a few pigs are kept, they may be treated by washing them thoroughly with a cloth or sponge wet with the dipping solution.

Besides dipping, the hogs should have short posts set for them in their yards and pastures. Wrap the posts with old potato or bran sacks and once a week saturate these sacks with crude oil. A louse bites the hog, he rubs the spot on the sack and the oil kills the louse.

When hogs are found to be lousy, their sleeping, feeding and resting places should be thoroughly cleaned, all bedding burned, and these places sprinkled or sprayed with the dipping mixtures.

Pregnant sows should not be run through the dipping vat.

SHELTER AND CONVENIENCES.

The average change in temperature each 24 hours in Colorado is 20 degrees. For hogs this necessitates a dry, warm shelter, free from draughts every night, both summer and winter. Hog cholera is found in Colorado only in localities where it has been brought from other states; but the losses in hogs from pneumonia and rheumatism are as great in Colorado as the losses in the corn belt from cholera, and are caused by needless exposure.

The beginner in hog raising should start with cheap shelter, and not put up any large buildings until he can do so from the profits of his hogs. Usually, after he has learned the business, he will not want large buildings. The shelter should be warm, light and dry, free from draughts, but well ventilated and easy to disinfect in case of disease.

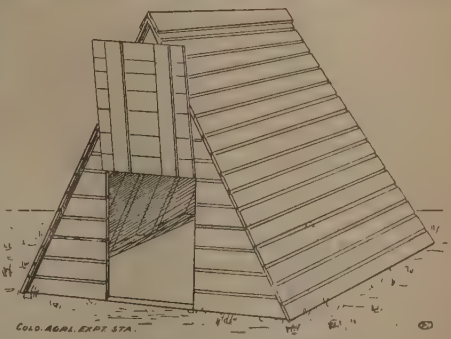
Hogs should be comfortably bedded, but it is best to use just enough bedding to keep them warm, and to change it once or twice a week. Where a large quantity of bedding is supplied it

becomes damp underneath, causing rheumatism; and dusty on top, giving the hogs a dry, hacking cough. Both dust and dampness are opposed to thrift.

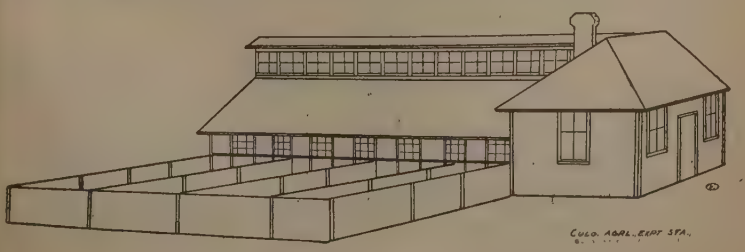
When hogs are not supplied with plenty of comfortable bedding in cold weather, they pile on top of each other to keep warm. In this way the under ones become heated, and when they get out into the cold air are easily attacked by pneumonia and rheumatism. If the attack is not sufficient to kill them, it makes them unthrifty. It is best to allow only a limited number of hogs to sleep together, and they should have such shelter and bedding that they can keep warm without becoming heated. Bathing in cold water in irrigating ditches is likely to result in rheumatism.

Hogs are more disturbed by wind than any other farm animals. Their shelter should thoroughly protect them from wind and from draughts.

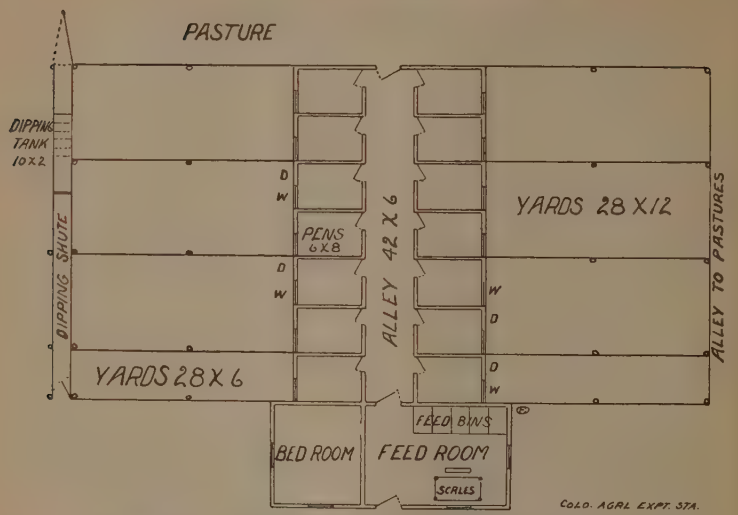
The Portable Hog House is cheap and convenient. It is eight feet wide, eight feet long, and the roof is eight feet in length, making the building seven feet high The door in front is two and a half feet wide, three feet high, and another at the back, near the top is 12x18 inches. The small door may be covered with heavy muslin, admitting air and light without draught. The frame is made of 2x4's and is covered with drop siding. No floor is used. When it is desired to move the building, it may be tipped over onto a low wagon or stone boat. This is the house we recommend for beginners. It is cheap, and often old material can be used in building it. It is easily moved and easily disinfected and can be changed so frequently that it may be kept on clean ground, free from disease. When a sow farrows in cold weather, a lantern hung to the roof will keep the building sufficiently warm.



Portable Hog House.



Piggery, Colorado Agricultural College.

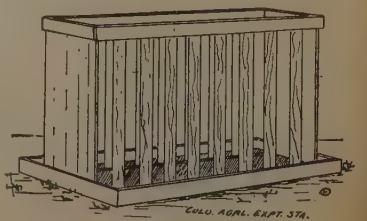


Ground Plan, Piggery, Colorado Agricultural College.

The Piggery of the Colorado Agricultural College, is a satisfactory building where a permanent one is wanted. The partitions between the pens are movable in case it is desired to use the building for fattening hogs. The doors leading to the yards are raised from the central alley by means of ropes and pulleys. A shute across the ends of one set of yards makes it an easy matter to dip hogs regularly. It is 6 feet to the eaves and 16 feet to the ridge above the pens. Additions to this house can be made when desired and the building remain just as convenient.

The Johnson Shelter for Fattening Hogs.—F. D. Johnson, Wray, Colorado, uses a portable shelter for fattening hogs that is the best for the purpose the writer has seen. It is a shed, open on the front only It is 16x16 feet, 4 feet high in front, and 20 inches high at the back. It has no floor, and is mounted on two runners 20 feet long, made of 4"x4" timbers. The front is boarded down 20 inches from the top. The roof is of battened boards and must not project beyond the sides or the stock will rub it off. The building can be moved easily by a team, and the low roof keeps the hogs from piling on each other and becoming over heated. This is the special advantage of this house and it is particularly adapted for hogs in the pea fields of the San Luis Valley.

Alfalfa Rack for feeding alfalfa hay to hogs. The rack is made of 1"x4" stuff. It is 3 feet high, 6 feet long and 16 inches wide. The top is open, the ends solid, and the 4-inch slats have four-inch spaces between them. The trough is 4 inches deep and extends 7 inches beyond the bottom of the rack.



Alfalfa Rack.

Bulletin 147 June, 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Top-Working Fruit Trees

BY

O. B. WHIPPLE

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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Top-Working Fruit Trees.

O. B. WHIPPLE

It is becoming more and more apparent that certain localities and soils are peculiarly adapted to growing particular kinds and even varieties of fruit. Commercial fruit-growing localities are making their reputation by being able to grow a few varieties well. So each new fruit country must go through an experimental stage when a host of varieties is being tested to determine those best adapted to its peculiar conditions. Then in the growth of each new fruit country there comes a time when the grower will have to solve the problem as to what to do with the undesirable varieties. Shall he pull them out or graft them over to better varieties? Systems of grafting-over old trees have long been practiced and experience has proven that, if properly done, top-working brings quicker returns than the replanting of young trees. It is not uncommon to see a fairly good crop on the three-year-old top of a top-worked tree. Trees properly worked-over give tops as desirable and sometimes more so than trees of the same variety grown from first-class nursery stock.

Top-working as a means of establishing a weak-growing variety on a stronger root system than its own is now coming into favor. The Rome (Beauty) when on its own roots is, on the best soil, an indifferent grower; but, when worked on some strong-growing stump, it makes a very satisfactory tree. Some varieties of apple, susceptable to attacks of root rots, could, no doubt, be successfully grown on roots of varieties which are apparently resistant. The Northern Spy seems to be a striking example of an apple tree root free from the attacks of woolly aphis and is sometimes planted and later worked over to other varieties. Broken and diseased limbs may be saved by grafting, and progressive fruit growers who desire to test new varieties can best do it by grafting a few cions into bearing trees.

Some years ago the fruit grower looked upon the practice of grafting as a mysterious art and upon the man who went about doing the work as a sort of a wizard; as a matter of fact, it is so simple that any careful orchardist can and should do it himself. All of our common fruit trees can be easily grafted or budded. The apple and pear may be intergrafted upon each other and the same may be said of the peach, plum, apricot and almond. But in practice, we do not carry on such wholesale mixing, it may be said that the apple and pear never make a good union. While such combinations may unite, the union may not be perfect enough to make a good top. We would not expect the top-working of apple to pear or vice versa to be a success. The writer has seen peach grafts start very vigorously upon apricot, and plums upon peach trees. I have observed

plum trees top-worked to peach with perfect unions and the ten-year-old tops bearing excellent crops of fruit. In this case, the combination seemed to result in a dwarfing of the peach top, though the growth is by no means stunted. So in practice, we stick largely to the intergrafting of different varieties of the same kind of fruit.

To understand the principles underlying graftage, the orchardist should know how the stems of our fruit trees grow. He should understand that growth in diameter only takes place in a very small region between the bark and sap-wood. This part of the stem is called the cambium. In this thin layer of tissue the cells are still active and capable of diversion while the activity of each succeeding layer, on either side, grows less and less.

FIG. 1.

When the limb is split to insert a cion the cleft does not grow together along its entire length, as some may think. The cells in the cambium layer may produce a growth that may, to a certain extent, fill up the cleft and cover over the stub but the tissues of the stock and cion only make a true union where the cells of the cambium layers of the two come in contact. Fig. 1 is a pen drawing of a section through a stub grafted two years before. The stub was kerf-grafted and shows that no union has taken place between the woody tissues of the stock and cion.

The important point in grafting is to see that the cambium layers of the stock and cion are matched at some point.

When growth is active we say the bark "peals." Budding is done during this period, not only because the ease with which the bark separates from the wood simplifies the work of inserting the bud, but as growth is more active, the tissues of the bud and the stock are more likely to unite.

TOP-WORKING OLD TREES

In the working overof old trees it is well to bear in mind that trees which show a poor growth in the orchard are seldom worth the time it takes to graft them. This is very often true in the case of some varieties of apple. For instance, I have never yet seen a yellow Transparent stock grow a top worth the space it occupied. The same is almost invariably true of tops on Wagner, Duchess, Missouri (Pippin), Wealthy and Hyslop crab. In fact, it seldom pays to top-work any crab. Figs. 2, 3 and 4 are from a series of photographs of a Transcendent crab apple tree, the first showing some grafts one year old and some just set; the second figure, the same tree one year later (quite a promising tree); and the third figure the result at the end of the third season, almost the entire top blown off by a heavy wind. The grafts were Winesap and were sent in a kerf, not a cleft. As a rule the weaker growing varities are very unsatisfactory stocks upon which to work other kinds.

Then the wisdom of top-working stone fruits would almost seem questionable. While good tops may be grown on either peach, plum, apricot or almond, it is doubtful whether these tops will bear much

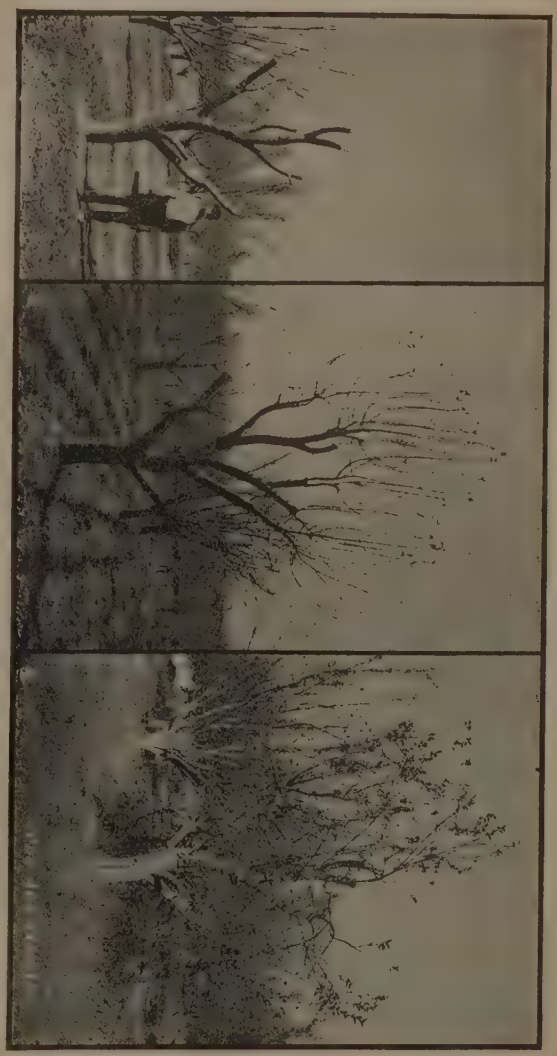

Fig. 2. An attempt at working over an old Transcendent Crab Tree, showing about as good a selection of stubs as is possible with such a subject.

Fig. 3. The same Tree one year later, with quite a promising top, but the enlargements at the base of the cions show that the union is not perfect.

Fig. 4. As the top grows heavier the unions are not strong enough to hold it and this is too often the result by the third or fourth season.

quicker returns than young trees set in the place of the old ones. Still we would not care to discourage a practice most successfully

followed by some growers, but will say that only strong-growing young trees under the most favorable conditions are worthy of such an attempt at renewal.

METHODS OF GRAFTAGE

Various methods of graftage may be employed in changing over the top of the old trees. Some method of cion-grafting is generally used, although it is not uncommon, in stone fruits especially, to bud into new growths. Of the methods of cion-grafting two are commonly used in the West; cleft-grafting and kerf-grafting. Those who have practiced grafting in the East as well as in the West, claim that the wood of Western fruit trees is much more brittle and that on account of excessive splitting, cleft-grafting is more difficult in the West. This has led to the introduction of a new system which is locally known as kerf-grafting.

Cleft-Grafting. The operation of cleft-grafting is very simple. The limb to be grafted is sawed off squarely leaving a smooth solid stump. The stub is split down about two inches with a grafting-chisel or knife. The chisel is removed and the cleft is wedged open with the wedge on the back of the knife or one provided for the purpose. The cion should be cut to contain three buds and should be of strong, well-matured wood of the previous season's growth. The lower end is then trimmed to a wedge leaving the first bud a little below the top of the wedge, and cutting the edge of the wedge opposite the bud a little thinner than the other. The cion is then driven firmly into place with the lower bud to the outside and a little below the top of the cleft, being sure to bring the inner bark on the outer edge of the wedge in contact with the inner bark on the stub. This is the important step in grafting, as it is between these parts that the union takes place. Sometimes the inexperienced grafter makes the mistake of setting the cion flush with the outer edge of the stock. On large stubs with thick bark it would be almost impossible to set a cion more illy matched than in this way. Some advocate setting the cion on a slant, the point of the wedge toward the center of the stub. This insures a contact of the cambium layers where they cross and is a good suggestion, since a point of contact is sufficient for a good union. With a cion properly set in each edge of the cleft—providing the stub is large enough—the wedge is removed. This allows the cleft to tighten on the cions, the greater thickness of the outer edge of the wedge-shaped portion of the cions insuring greater pressure at this point. With the removal of the wedge the cleft should hold the cions firmly in place. Wax should now be applied to all cut surfaces, even to the tips of the cions. Special pains should be taken to see that the stub is well covered between the cions and the cleft waxed as far as it extends down on the sides of the stub. This prevents drying out and it is quite important that it be thoroughly done.

Kerf-Grafting. This system of grafting differs little from inlaying. The stub is prepared as for cleft-grafting, but instead of splitting, saw cuts are made on opposite edges of the stub and trimmed

to thin V-shaped grooves with a saddler's knife. The cion is then trimmed to fit, driven firmly into place and waxed as in cleft-grafting. With a little practice the cions may be set as firmly as in cleft-grafting. It is claimed that this method has the advantage in speed and that the cions are not as easily blown out in early summer. Cions are lost by both methods and if properly performed, one is probably as good as the other. It does have the advantage in that more cions may be set in large stubs and thus hasten the process of healing. The same care must be used in setting the cion to insure a union. The latter system seems especially adapted to working with stone fruits where splitting is even more noticeable than in the apple and pear. Sharp tools which give a smooth cut surface are essential in all grafting work.

Bark-Grafting. Some advocate another method of grafting known as bark-grafting. In this case, the stub is cut as before, the cion is cut with a long bevel on one side and slipped between the bark and sapwood. It is generally necessary to slit the bark at the point of insertion and very often the bark is removed from the base of the cion up to the top of the sloping cut. The stub is bound with waxed string or other material, to hold the cions firmly and it is then waxed as in the cleft-grafted stub. The system really has no advantages over the others, unless when compared with cleft-grafting in working large stubs.

Terminal-Grafting. Another style of grafting sometimes employed is that known as terminal-grafting. This work is generally done in the latter part of June or just as soon as new growth that has matured enough to show a terminal bud may be secured. On old trees, such wood may be found in June. A twig that has completed its growth may be picked out by the presence of a well-formed terminal bud at the tip and full grown, or practically full-grown terminal leaves. The cions are cut three or four inches long and the leaves practically all trimmed off. There are different ways of inserting the cion. The most common method is to cut a vertical slit in the bark of the stock, trim the lower end of the cion with a long sloping cut on one side, and then slip it under the bark at an angle of about 45 degrees with the slit. The cut surface of the cion should rest upon the wood of the stock. It is not necessary to wrap or even wax the wound.

The cions start into growth the same season but the top of the stock is left until the following spring. The method seems to work well. It may prove a practical way of supplying lower limbs on young trees headed too high. When one neglects to remove the top when such grafting is done in the lower part of old trees, these cions readily form fruiting wood, generally bearing the third season. It is a suggestion that it would be the proper course to take as a means of getting specimens of new varieties in the shortest length of time.

CHOOSING THE STUBS

There is much to be gained by the proper selection of stubs into which cions are to be set. A too common practice is to remove the whole top the first year and graft all the stubs. It is surprising

that some good results come from such a practice. More often, however, this proves too much for the tree and it fails even after the grafts have made a good start. They may linger two or three years and then die from no other cause than the severe cutting back, though the growers are prone to attribute it to some other affliction. The cutting away of the greater part of the top seems to give good results and may even be advisable in top-working stone fruits. The pear will stand much more abuse in this respect than the apple. A far better plan in all cases, is to cut away only enough limbs to set cions for a good top. This will generally be about half of the tree, as six stubs will, in most cases, provide for a good top. The working of more stubs results in too dense a top or necessitates their removal later. The remaining limbs may be shortened but some foliage is needed to protect the stubs and trunk from sun-scald as well as to supply nourishment. If the stubs are well chosen the remaining limbs will do much to protect the young grafts from wind and especially from being brushed out by passing teams and orchard machinery. It is well to choose inside limbs for grafting as they are best protected, but care must be taken not to contract the head of the tree too much. It should be borne in mind that top-worked trees tend to grow upright, but it is a difficulty which may be largely overcome by judicious pruning.

After the cions have made one year's growth much of the remaining top may be removed, but it should seldom all be removed from old trees before the second year. If some stubs have met with accidents or have failed to start the cions, or if the shape of the tree or a scarcity of scaffold limbs has prevented a full top being placed the first spring, it may be completed the second.

Fig. 5. Showing proper selection of stubs.

While we sometimes see grafts doing nicely in stubs six inches in diameter, it is very doubtful whether such grafts will make a strong union or a long-lived tree. The wisdom of working limbs over three inches in diameter is to be doubted. In the choosing of stubs the grafter should remember that large wounds properly made, heal more readily than large stubs. Choose the smaller limbs for grafting even though the later removal of the top may necessitate the cutting of larger limbs lower down. It is better to raise the head of the tree than to work large stubs. Fig. 5 showing a two-year-old top on a pear tree will illustrate this point; notice the large wounds below the grafted stubs.

SEASON FOR GRAFTING

The ideal time for grafting is just as the buds are beginning to swell. While cions may be set earlier, there is danger of their drying out before a union is established. Should one care to prolong the season, it is better to run late than to begin early. The opening of the season will vary from the first of March to the first of April or even later in some parts of the state, and may be extended until the first leaves are practically full grown. Good results cannot be expected from cions set later than this. Some go through the orchard in winter and remove the tops of the stubs that are to be grafted, cutting them at least a foot above where the cions are to be placed. This saves some time, and by hauling the brush out before the grafts are set it saves some of them from being knocked out by careless men in removing it later. When ready to graft, the stub is recut from a foot to eight inches lower.

PROTECTING THE BODY

Since the removal of any considerable part of the top often exposes the body of the tree to the direct rays of the sun, it is well to whitewash the trunk and main branches. The whitewash reflects the rays of the sun and by such an application many cases of sun scald may be avoided. A good whitewash may be prepared by using one pound of good quicklime to each gallon of water. The addition of a pound of salt to each three gallons of the wash tends to make it stick better. This can best be applied with a spray pump. A good coating can only be secured with two applications, the second to follow as soon as the first is dry.

CION-WOOD

In this connection it is well to say a word about the selection of cion-wood for grafting. The man who is interested in his bearing orchard has early learned that the individual trees in the plantation show a great variation, especially in productiveness, and very often in the size, color and quality of the fruit. Some of this variation may be accounted for in various ways, but after all, we are coming to believe that, environmental conditions being equal, no two trees are alike in bearing habits. It is a natural variation. There are trees that never bear well and cions from such trees will, no doubt, produce trees very much like them. In the selection of grafting wood it is well to bear this in mind. Mark your favorite trees and select cion-wood from them.

The wood used should be one year old, strong and well matured, but not overgrown. The terminal shoots from trees that have made a growth of from twelve to eighteen inches make excellent cions. The question is often asked as to the use of watersprouts. The term watersprouts may mean different things to different people. By watersprouts we generally mean rank growth from adventitious buds; and such growths with immature tips, weak buds far apart, and pithy centers make very poor cion-wood. Otherwise, any new wood with well developed buds, comparatively close together, may be used

for cions. The statement sometimes made that watersprouts never produce fruit is erroneous.

Cion-wood should be gathered in the fall, preferably as soon as the leaves have fallen, and stored until spring. The object is not to avoid winter injury, as some think, but to keep the cions in a dormant condition. Few realize that buds complete the resting period early in the winter and may, under favorable conditions, begin to swell before the first of January. While the unobserving man may say there is no difference in the buds of the young growth in early December and in February there may be quite a marked difference in some climates. Our open winters in the Middle West are especially liable to start early growth. The object of keeping the cions dormant is to allow time for a partial union before the buds are started into growth by the warm days of the grafting season. Cions with buds well swollen often throw leaf surface before a sufficiently strong union has been made to support them. The result is the exhaustion of the stored-up food supply and moisture of the cion to a point which may cause its death.

The cions may be stored in sand in a cool corner of the cellar or buried out of doors. The main object is to keep them cool and moist and away from fluctuating temperatures. An excellent plan is to bury them on the north side of a building or in some spot shaded most of the day. They need not be buried deep, from twelve to eighteen inches being sufficient in a well shaded spot.

GROWING THE TOP

It would hardly seem wise to leave the subject of top-working old trees without some comment on future treatment of the grafts. The setting of the cions is only the first step in working over the tree. Should we stop here, a most miserable failure or, at least, a poor top would be the result. Many a good catch is ruined by neglecting the pruning the first two seasons. During the first season the grafts should make a very rank growth and they will require some pinching back to save them from becoming top-heavy and consequently easily blown out. The common practice is to head-in the rapidly growing shoots when they have attained a length of from eighteen inches to two feet. This forces branches from below and if growth becomes too heavy these may need cutting back before the season is over. This pruning insures stockiness of the new growth and throws much of the energies of the top into a good union. The growth of suckers or watersprouts from the stock should not be allowed to any great extent. Should the stubs be exposed to the direct rays of the sun it is well to leave some of this growth, pinching it back to cause it to form a dense shade. Unless needed for protection it is well to rub the sprouts off as fast as they appear.

The following spring the system of pruning should resemble very much that of pruning young trees. The growth of the grafts should be cut back to usually not over eighteen inches in length. They may be cut even shorter if the growth has not been satisfactory. If all three buds have started from a cion, it is well to remove all but one to avoid crowding. As a rule the growth from the lower

bud will be the strongest and should be retained. Should the formation of the top allow it, a second growth may be left. If the grafts have been set in near the head of the trees they will require some pruning in reference to spreading the top. The general tendency is for the top-worked tree to grow too compact. Cut the grafts back to one of the strong outside branches started by the first pinching back and it will give them a start in the right direction. What shall we do where two cions start in the same stub? Should the stub be less than three inches in diameter one should be removed at this time. Keep the stronger, or if there should be little difference, the one best situated to help make a good top. Cut the other off close, even to removing a small corner of the stump on that side, the wound will heal better. Should the stub be over three inches in diameter there is some argument in favor of leaving the extra graft another year. It will help callous over the stub, and may be removed the following spring leaving a comparatively small wound. If left longer, or until the two grow together, the result is a bad crotch and sometimes a pressure which may actually split the stub.

Subsequent pruning will consist in such cutting back as will help form a stocky and well shaped top. They will demand the same attention as young trees. Spread the top by pruning to outside buds or branches and do not pay too much attention to the small wood. Some of the small branches may require cutting out or clipping back, but remember, in it we have the start for early fruiting wood.

TOP-WORKING YOUNG TREES

There is a growing conviction among the fruit growers that better results may come from planting vigorous young trees of some strong, growing kind to be later worked over to the desired variety. In the opening remarks on this subject, mention was made of the desirability of working weak growing kind on stronger root-systems, as well as top-working as a means of lessening loss from attacks of root rots and woolly aphis. The embarrassment of growing the orchard to a bearing age, only to find some of the trees not true to name may be avoided by this plan of starting the young orchard. Then every fruit grower has observed that few trees of the same variety are alike in bearing habit and character of fruit. No doubt, many growers have some particular tree in their bearing orchard which is better than all others, that is nearer their ideal. By choosing grafting wood from this tree, a young orchard may be grown as near like it as is possible. There are productive and unproductive trees in every orchard and the careful selection of cions from productive trees will avail much as means of building up a fruitful orchard.

In top-working young trees it is a common practice to set the trees where they are to grow and after the scaffold limbs are well formed, to graft or bud into these the future top. Some Eastern men have advocated purchasing two-year-old trees in the fall (trees in which the head is already formed) to be grafted over indoors in December. In the West, and especially on a large scale, this system

would hardly seem practical. The method of grafting in this case is whip-grafting.

GRAFTING

In grafting young trees in the field it is probably well to do it as early in the life of a tree as possible. As soon as a good strong framework can be secured the tree is ready for top-working. The small size of the stubs make cleft-grafting difficult and kerf-grafting almost out of the question. Some growers, however, report good success in cleft-grafting young trees after two year's growth from a yearling whip. In this case the stubs must be bound with waxed cloth or other material to hold the cion firmly, and then waxed as in cleft-grafting larger stubs.

FIG 6

Another style of grafting, known as whip-grafting, is well adapted to working these small stubs of young trees. The process is well illustrated in Fig. 6. With this style of grafting it may be possible to set the cions after one year's growth in the field, but it is doubtful whether much time will be gained by such practice. The cion should be as near the size of the stub as possible, if anything, a little smaller. The cambium of the stock and cion is matched only on one side, paying no attention to the other. The joint should be well wrapped with waxed cloth and to be doubly sure all air is excluded, may be painted over with a warm wax.

In grafting young trees it is a common practice to remove all of the top, placing cions in those arms one wishes to keep. It is always well to work a few extra stubs as accidents may befall some of the cions. The season for top-grafting the young trees is the same as for old trees. While top-working the old trees tends to hasten the bearing of the cions, it is doubtful whether top-working young trees induces earlier fruitfulness.

BUDDING

This is no doubt the simpler method of putting a new top on young trees. While the process of budding is a little more delicate than that of grafting, the average man can, with a little practice, get very satisfactory results. Buds should be placed as soon as the top is well formed, setting one or two in each scaffold limb that is to be retained. The buds are generally set from six to twelve inches from the main stem, depending on the formation of the head. Trees two years old when set may generally be budded the following fall, and should yearling whips make a strong growth, the arms may be large enough to receive buds in September. Any stem as large as a lead-pencil may be budded quite easily. Arms in which buds fail to start may be grafted the following spring. Should arms fail to appear in the proper place it is quite possible to supply them by setting buds directly into the body of the young tree. When the

buds begin to push into new growth they will require about the same care as young grafts. They will need some pinching back to strengthen the stem and to overcome the tendency to become top-heavy. With the possible exception of young trees budded in late spring, all growth from the original stock should be removed as fast as it appears.

Buds may be set during the month of June or early July, or in August and September. For June budding the bud-sticks are cut as soon as well matured wood may be found. Good firm wood with well developed buds may generally be cut from bearing trees in the latter part of June. As soon as buds set in June or July unite with the stock, the bandage is cut and the part of the stock above the bud is removed. In spring-budding it is well to leave some of the new growth which springs from the arms below the bud. This takes the surplus sap and helps nourish the roots until the buds are well started. Wood from buds set in the spring may not mature well in our climate and is susceptable to winter injury during severe winters. With careful watering it is possible to mature the wood properly, but where practical, fall budding should be given the preference. In the case of peach trees, June budding is preferred where attacks of twig borers often destroy in early spring, buds set the previous fall. In the apple and pear it is probably more convenient to bud in the fall. Then, too, arms which are large enough to bud in early spring were large enough the previous September, so one really gains rather than loses time by budding in the fall.

In fall budding the buds are taken from the current year's growth. Buds may be inserted in wood of one, two or three years' growth. The stiffness of the bark of the other wood makes budding difficult.

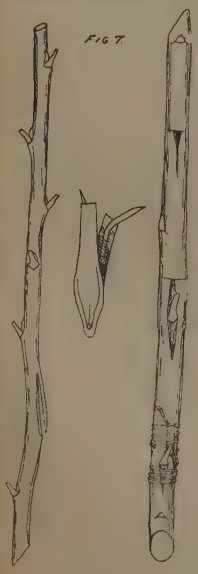
FIG 7

The heavy bark not only makes the insertion of the bud difficult, but in drying out it curls away from the bud exposing it to the air. The simplest form of budding is that known as Shield-budding or T-budding. The position for the bud is chosen with reference to the prevailing wind, protection from the sun's rays, or to best form the top of the tree. The most important factor should determine where the bud should be placed. It is well to place the bud on the shady side of the stock, if possible. Should the locality be subject to strong prevailing winds, the bud should stand more wind if placed on the side of the stock toward the wind. A T-shaped incision is made in the bark and the corners of the bark below the transverse cut raised to facilitate starting the bud. The bud is then cut from the bud-stick by starting the knife half an inch below the bud, cutting under and to about the same distance above the bud. This gives a long bud which is especially desirable in our dry climate. In cutting under the bud, the knife should be run deep enough to leave a small shield of wood. Fig. 7 will show the various steps in the process of shield-

budding. A simpler method of lifting the bud, at least for the beginner, is to start the knife as before, and cut sharply into the wood to about one-third the diameter of the stick and then upward under the bud making a tongue about an inch long. The knife is then run across the tongue half an inch above the bud, cutting through and lifting the bark at this point. The bud is then grasped between the thumb and first finger and lifted, leaving the wood on the stick, as shown in the same figure. While the removal of the wood from under the bud is no particular advantage, the method is simpler and gives the inexperienced budder a larger per cent. of good buds. The writer has lifted thousands of buds in this manner with the best of success. It is difficult to cut buds in this way from some varieties of cherry and plum trees with thin bark, but it works well on the apple, pear, peach, apricot and the heavy-barked plum. The bud is then slipped into place as shown in the figure and well wrapped with raffia or soft wrapping twine. About four wraps below and three above, so spaced as to close the whole opening, is sufficient. In wrapping, the common practice is to start below, and by crossing over the first end and running the last end under, the bud is wrapped without a knot. The tying material is usually cut in the desired lengths beforehand, and if raffia is used, it should be kept moist, as it ties better.

If on healthy young wood, the buds will unite within ten days or two weeks. Then the wrapping should be cut by drawing a knife across it on the side of the stock opposite the bud. Should the stock be making a slow growth, there need be no hurry about cutting the tie. The only thing to be guarded against is that the wrap does not cut into the bark. This pressure interferes with the flow of sap, and tends to throw the bud into premature growth, this often means a loss of the September bud. The bud set in August and September should remain dormant over winter. The following spring, just as soon as the buds on the top of the stock begin to push out, the original top of the stock is cut away. Should the stock be cut off too early in the spring, or too close, there is danger of the stub drying out to the injury of the bud. Some recommend the practice of leaving a longer stub to which the young growing shoot from the bud may be tied until it is well established. This saves some buds from being blown out, but necessitates a second cutting in mid-summer to allow the stub to heal over.

We have said that buds for fall budding should be taken from the current year's growth. The common practice is to cut the terminal growth from bearing trees. The leaves are trimmed off at once, leaving a small part of the leaf-stalk to handle the bud by. Bud-sticks trimmed in this way may be stored in a cool, damp place and kept for some time without injury. The leaf-stalks, however, will losen and drop off in many cases if stored over ten days. Of course, this does no harm, but some budders miss the little handle in inserting the bud. The first few buds at the base of the stick are generally poorly developed and should be discarded while those near the tip are too immature to be used. As a rule not over half of the new growth cut in early September will carry buds suitable for budding. The sticks should be carried in a damp cloth to avoid drying out.

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*Out of Print.

Bulletin 148 June, 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

CEMENT AND CONCRETE FENCE POSTS

BY

H. M. BAINER
H. B. BONEBRIGHT

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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CEMENT AND CONCRETE FENCE POSTS*

H. M. BAINER†
H. B. BONEBRIGHT‡

PART I.

INTRODUCTION.

The average life of the best wood fence posts that have not been specially treated is from 12 to 15 years; while the poorer ones often last but from 3 to 5 years. Good wood posts are gradually becoming harder to secure and the cost of them is increasing each year. The cost of maintaining the farm fences and especially the posts is a great one when we consider that they must be replaced so often.

The cheaper and poorer grades of woods used for fence posts can be treated and thus made to outlast the best grades of untreated timber. The cost of the untreated post will vary from 10 to 15 cents each and the cost of treating them according to experimental data at hand will add from 10 to 15 cents each to the first cost, thus making the total cost of the treated post from 20 to 30 cents.

With the present enormous and increasing demands made upon our forests for all classes of lumber, shingles, pulp wood, cooperage stock, mine timbers, lath, wood for distillation, poles and fence posts, there is no wonder that the prices for these products are becoming greater. The cost of the average fence post is almost double what it was a quarter of a century ago and in another quarter of a century, there is no doubt but that its cost will be double that of the present.

Iron fence posts cannot be generally used as substitutes, as their cost is prohibitive. Stone posts are used in some localities, but they do not give general satisfaction and they cannot be profitably shipped.

Cement and concrete posts are just beginning to be manufactured and used as substitutes, and there is no doubt but that they will become more generally used. It is true that they may be considered as expensive, but they are long-lived, present a good appearance, and can be made by the farmer, providing the necessary materials are available. It is the purpose of this bulletin to show how to make the posts and also to determine the best forms, mixtures, reinforcements, wire fasteners, cost, and general practicability.

MATERIALS TO USE.

Cement.—There are but two general classes of cements which could be used for post construction—Natural and Portland. The

*Copy received June 26th. Expense borne by State appropriation, 1907.
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materials found in Natural cement are mixed by nature in approximately the correct proportions and when burned does not always make a cement of uniform strength. Portland cement is mechanically mixed in chemically correct proportions. Portland cement makes a uniformly stronger mixture than the Natural cement and is always used where great strength is required.

In cement fence post construction, it is desirable that the post be made as light and as strong as possible, and thus it is practical to use nothing but the best grade of Portland cement.

Sand.—Clean, sharp sand with grains varying in size from small to large makes the best mixture. By clean sand is meant that which is free from clay, loam, or foreign materials. These tend to retard the proper setting of the cement and destroy its adhesive quality. In many sections mica is found mixed with sand in large enough quantity to seriously interfere with the strength of a mixture made from it.

Sharp sand is composed of sharp, angular grains of all sizes and makes better mixture than that which is smooth and round, or "river worn."

A sand composed of fine and coarse grains mixed, is to be preferred, because less cement will be required to fill the voids than either used by itself.

Leaves, sticks, stones or gravel should be removed by screening.

Gravel.—The same general rules used in the selection of a good grade of sand will apply to gravel. It should be composed of clean, sharp pebbles of all sizes. For post construction, the pebbles must not be too large, as they will interfere with the proper placement of reinforcement.

Broken Stone.—Broken stone used for post construction must contain no large pieces as they will interfere with the placement of the reinforcement. It is necessary to use some sand with the stone to fill voids and thus save cement. It is not desirable to use soft sandstone, soft limestone, slates, or shales. Granites, hard limestones, and coarse gravel which has been crushed, is considered best.

Water.—The water used in making a cement or concrete mixture should be clean and free from alkali. Satisfactory experiments have not been conducted to show the effects of alkali water used in making a mixture of this kind, but enough is known as to its effect on cured cement constructions to justify not using it in the mixture.

PROPORTIONS.

On account of a difference in the total open space or voids in sands or gravel composed of different sized particles and also that more cement is required in some conditions than in others, it is of-

ten necessary to make a rough determination of the percentage of voids to the total aggregate. Where maximum strength is required about 10 per cent. more cement should be used than the total voids.

The determination may be made as follows: Secure a water tight box or pail of known capacity, fill it with the aggregate to be used so that when it has been well shaken it will smooth off even at the top. Pour water of known amount into this until full. The volume of water used in proportion to the total volume of the receptacle determines the total voids.

For example, suppose the total volume of the receptacle in which the aggregate is placed is 2,032 cubic inches and that it takes two gallons of water to fill it. One gallon of water contains 231 cubic inches and two gallons would contain 462 cubic inches. The total volume of water used, divided by the volume of the receptacle holding the aggregate represents the proportion of voids. Thus, 462 divided by 2,032 equals 22.73, or the voids make up 22.73 per cent. of the total volume. For the maximum strength 10 per cent. should be added to this. Ten per cent. of 22.73 equals 2.27. By adding this 2.27 to 22.73 we obtain 25, or in other words, 25 per cent. of the total volume should be cement. The mixture in this case would be represented by one part of cement to four parts of aggregate.

The proportions used in the constructions of the fence posts in this bulletin varied from 1 part cement and 3 parts of sand to 1 part of cement and 5 parts of sand. In others gravel was used in the proportion of 1 part cement, 3 parts sand, and 3 parts gravel. It is a difficult matter to use broken stone or gravel in large quantity and place the reinforcement properly.

Measure all materials in correct proportions. This may be done with a shovel, a pail, wheel barrow, or barrel. It will usually be advantageous to measure the water, especially where small quantities are mixed or where the same amount of mixture is made several times.

MIXING.

Hand Mixing.—Where the mixing is done by hand, a flat water-tight platform, or shallow box is convenient. Measure the sand and place it in a uniform layer and over this spread the proper amount of cement. Mix this thoroughly before adding water until it shows a uniform color. The rule is to shovel it over at least three times. Now spread out the mixture, making a sort of basin in the middle into which the greater part of the water may be poured. Work in the dry edges until the water disappears, then add enough more water in small amounts to make the mixture of the desired consistency. Do not mix more material than can be used in twenty minutes.

Machine Mixing.—It is usually customary to use mixing machines on large jobs. It is not only economical, but does better work. Where power is available it is often advantageous and economical to construct a mixer for small jobs, also.

A small mixer can be cheaply constructed which can be driven with a two or three horse-power gasoline engine. With this, it was found that two men were able to do the work of at least four men doing hand mixing, and the machine work was done more thoroughly.

In many instances, mechanical mixers, which are driven by hand power instead of by an engine are better than hand mixing with shovels or hoes. A mixer of this kind can be made from a barrel or box, pivoted in the center and driven by means of a crank on which one or two men can work.

The mechanical mixer first mixes the materials in a dry condition, then some provision is made for turning in the water without stopping the machine. With most mixers of this kind, one revolution does as much mixing as one turning by hand. Six turnings by hand are considered enough, and it is seldom that a machine is stopped with less than double this number of revolutions; in fact, it may be turned 15 or 20 times; thus this method of mixing is very much more thorough and desirable.

HOME MADE CONCRETE MIXERS

To many people, the idea of mixing the concrete by hand appears to be an unnecessary task. But the price of a modern concrete mixer is so large that it would not be good economy to purchase one for what little mixing is done on the average farm.

The ingenious farmer will find that a suitable mixer may be constructed at home with little expense and work. All that is necessary is the ability to put a few pieces of old machinery together in such a way that the barrel or box may be turned upon an axis and stopped at the desired time. This is very easy in case the power is furnished by hand, but in case of a power-driven mixer, more ingenuity is required.

The home made mixer shown in the cut illustrates how a few pieces of board and timber may be turned into a very serviceable machine. Two pieces of 4x6 form the sills. Upon these, two uprights about three feet high, are fastened. A 1½ inch pipe passes through holes bored in the top of the uprights. Upon this pipe the mixing box is turned, and through the pipe the water is added to the mixture at the desired time. The water is poured in at the top of the upright pipe and flows down and out through holes which are drilled in the lower side of it. The other end of the pipe is closed by a wooden plug. The ends of the box are made of pieces of 2x8 bolted together. A hole bored in the center of each end forms the

bearings. The sides of the box are made of one-inch lumber and are simply nailed to the ends with 12d nails. One-half of the box is made so that it can be detached and lifted off when the mixer is to be filled, or emptied. The detachable half is secured to the other half by means of strong hooks so placed that by slipping this half about an inch to one side all of the hooks are loosened at once. After it is in position, the removable portion is held in place by means of a barn door latch.

The driving gear is simple but very effective. It consists of the rim taken from the wheel of an old "rubber-tire buggy." With the tire removed the grooved rim makes a very satisfactory wheel upon which to run a ¾-inch rope belt. The belt is driven by a small shieve pulley which is fastened to the counter shaft. A belt tight-

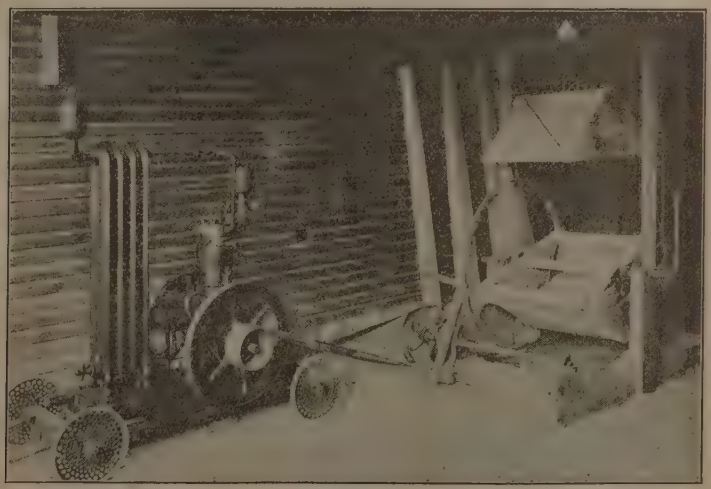

Figure 1.
Home made concrete mixer operated by 2-horse-power hand portable gasoline engine

ener is used upon the rope, and by using a very loose belt, the tightener is made to act as a friction clutch.

This particular mixer is driven by a two-horse gasoline engine, which is belted to the counter shaft. The engine runs continuously and the mixer is started and stopped by means of the belt tightener.

The operator first fills the mixer about half full of sand, gravel and cement in the correct proportions. He next lowers the lid, which until this time has remained supported upon the hook. The lid is now pushed into place and the latch fastened. The supporting hook is next removed from the staple in the lid and hooked into a

staple in the lid support. The machine is now ready to start, the clutch is thrown in, and the box revolves upon the pipe. When three or four turns have been made, water is poured into the upright pipe until the desired amount has been added. By this time the concrete is thoroughly mixed. The clutch is loosened, the box stops revolving, the hoisting hook is hooked in the staple of the lid, the latch is loosened and the lid raised to the top of the lid support by means of the counter weight and rope. Now, by slightly setting the clutch, the contents of the mixer are dumped into the box beneath. The operator of the machine may now refill the mixer, while the other workmen take care of the mixed material. In this way a large amount of material may be run through the machine and perfect mixing is guaranteed.

Many other systems of driving might have been used in place of the rope belt. The main gear of an old self-binder makes an excellent gear for a mixer. An old mower gear may also be put to good use in this connection.

It is not necessary to have the mixer driven by an engine or horse power. A crank may be attached and the machine turned by hand. Many prefer turning such a machine rather than mix the concrete with a shovel.

POURED POSTS.

There are two general classes of mixtures which may be used in the construction of posts; the poured and the tamped: In the poured mixture, enough water is used in mixing to make it thin enough to pour from a pail or scoop almost like water. The mixture is poured into a mold and allowed to remain in it until it has set, which is from one to five days, depending upon the time of year and the weather. In drying summer weather, from one to two days is usually sufficient. In cool or damp weather they must be left in the molds much longer.

In order to make several posts of the poured type at once, it is necessary to have several molds ready for use. With 6 molds only 6 posts could be made at once, and it would be necessary to wait until the cement was set before 6 more could be made.

It was found that to make a good poured post, the mixture should be stirred or shaken immediately after placing in the mold. This should be done carefully to prevent displacement of reinforcement wires. This helps to remove the air from the mixture and makes a post of smooth finish.

The experiment showed that a poured post of a certain mixture was stronger than a tamped post of the same mixture. It is enough stronger to justify anyone in constructing it in preference to the tamped one at the necessary additional expense for molds. The poured post is smoother, more nearly impervious to water, not so

hard to cure, stronger, somewhat more expensive, and can be better recommended than the tamped one.

TAMPED POSTS.

The tamped post is one in which the mixture contains very much less water than the poured one. It contains just enough water to make it hold together well when tamped. In the manufacturing of this type of post, only one mold is necessary. The mixture is tamped into it, and the sides of the mold can be removed immediately, the post remaining on the bottom piece until the cement has set. Thus the same mold can be continuously used for making as many posts as are desired. The necessity for but one mold makes this type of post less expensive than the poured one. The results of the tests made, show that the tamped post is inferior to the poured one and cannot be placed in an equal class with it.

On account of less water being used in the mixture for a tamped post than in the mixture for a poured one, the tamped post requires more water and attention in curing. It is of more open texture, less impervious to water, not as strong, and not as desirable as the post of the poured type.

POST MOLDS.

In general, the molds in which cement or concrete posts are made may be divided into three main classes.

First, those molds which are designed exclusively for manufacturing tamped posts.

Second, those which are made exclusively for manufacturing poured posts.

Third, those which may be used for either tamped or poured posts.

In the first class of molds we find mostly the heavy cast iron forms which are built of strong and heavy material. The most of these molds are designed to be laid upon pallettes or upon a smooth floor. The mixture is first tamped in the mold to a depth of about one inch. The reinforcement is then placed and the mold is next filled, and the mixture tamped, so that only about one inch of material remains to be filled in. The second set of reinforcement wires is put in place next and the mold is tamped full to overflowing. The last step consists in smoothing off the top of the post with a trowel and removing the mold. This is done by unfastening some form of hook or clasp, slipping the sides of the mold a little distance away from the post, and then removing the molds to the position chosen for the next post.

The principal advantage of these molds lies in the fact that they being made of heavy iron need no center stays. This gives greater speed in operation, due to the fact there are no cross pieces

to interfere with the placing of the reinforcement, the tamping of the mixture, and the smoothing off of the top of the post at the finish.

The cast iron molds being heavy, are rather hard to handle, and this feature, in connection with the high price of them, explains why they are not more commonly used.

In the second class of molds (molds for poured posts) we find a far greater variety. The more common forms are made of sheet

Figure 2.

Different Types of Post Molds.—1. A 5-inch home made mold for making poured or tamped posts. 2. An 8-inch home made mold for making corner posts. 3. A 4-inch commercial post mold. 4. A 4-inch heavy sheet iron mold. 5. A 7-inch heavy sheet iron mold for corner posts. 6. A triangular sheet iron mold. 7. A commercial reinforcing truss. 8. A double mold lined with sheet iron. 9. A heavy cast iron mold made especially for tamped posts.

iron, either galvanized or plain. For posts having a continual taper from top to bottom, sheet iron molds prove very satisfactory, providing sufficiently heavy material is used in their construction. A mold made of thin iron soon loses it shape and the posts made in them are necessarily unsightly. If properly taken care of, there is no advantage whatever in galvanized iron molds over those made of plain iron.

The advantages of the sheet iron mold are many. They are light to handle and easy to keep clean. If properly made they are nearly water tight. This insures the user against the possible loss of cement by leakage. As the cement travels to some extent with the currents of water, it can easily be seen how a leak in a mold may materially weaken a poured post by allowing a portion of the cement to be carried out of it. Another marked advantage of the sheet iron mold lies in the fact that the surface being smooth, im-

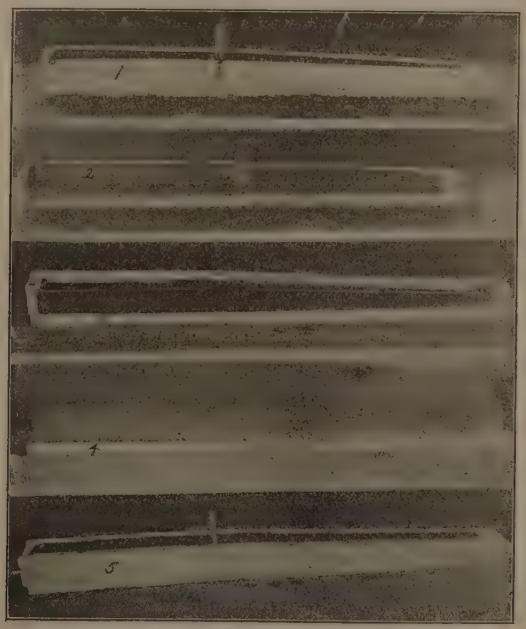

Figure 3.

1. Empty mold ready to be filled, showing tie hole pins in place. 2. First layer of mixture and first reinforcement wires in place. (Side of mold removed.) 3. Second filling of mixture and the second reinforcement wires in place. 4. Post completed, mold removed and the hole pins being pulled. 5. Post complete ready to remove mold.

parts a very smooth, glossy finish to the surface of the post. This not only adds beauty to the post, but aids in keeping out water, which might otherwise enter the cured post.

As the sheet iron molds are made in one piece, no pallette is necessary. At first glance this looks like a great advantage, but upon further consideration we find that the mold must be left upon the post until the mixture has set to such an extent that the post may be removed and handled without fear of breaking. In hot

weather the post may be removed after 48 hours, but in cold weather a much longer time is required.

In making poured posts in these molds exactly the same process is followed as with tamped posts in molds of the first class just described; with the exception that the mixture is not tamped and greater care must be exercised in preventing the reinforcement from being misplaced.

Some forms of wood molds are made and used for the purpose of making poured posts only. Any desired form may be given to

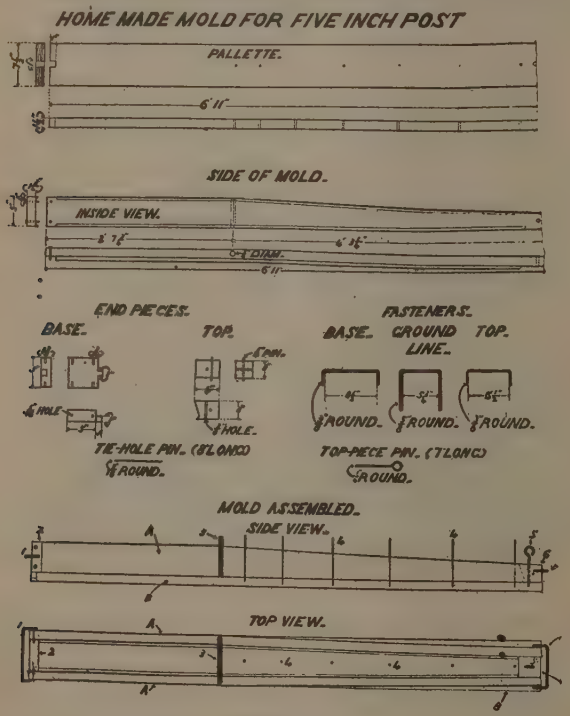

Figure 4.

A Home Made Mold Giving the Proper Shape to the Post.—1. Base fastener. 2. Base end piece. 3. Ground line fastener. 4, 4, etc. Tie hole pins. 5. Top piece pin. 6. Top end piece. 7. Top fastener. A. Side of mold. B. Pallette.

the post by properly shaping the mold. This point, in favor of the wood mold, is an extremely important one, as it permits the post to be made of uniform size from the bottom to the ground line, but with a rapid taper from this point to the top. Then, too, the sides

of the mold may be removed after 24 hours and used again in connection with other pallettes; while the post which has not yet become sufficiently strong to be removed from the pallette lies unmolested in its original place until it is ready to move. This enables the maker of cement or concrete posts to produce at least twice as many posts with wood molds as with the same number of sheet iron molds, providing the required number of pallettes are at hand. The number, as well as the extent, of leaks in a wooden mold will depend upon the accuracy of construction, the care with which the molds are handled, and the care with which they are put together before filling.

The third class of molds (those which may be used for making either the tamped or the poured posts) are much the same as the wooden molds for poured posts, except that they are stronger. A mold which is to be used exclusively for manufacturing poured posts may be made of ¾-inch material and prove strong enough for the purpose; while if the mixture is to be tamped within the mold, at least 1½ inch material must be used. The extra thickness is required to prevent the molds from bulging at unsupported places during the tamping process.

The heavy cast iron molds could be used in making the poured posts as well as the tamped ones, but their original cost make them impracticable. The wooden molds serve the purpose equally well and are much cheaper.

Selecting the Mold.—The first and most important point to be considered in selecting the mold is the *shape and size* of it. Too many post mold manufacturers are turning out forms of molds that make "freak" posts, simply because it happens that they can manufacture them more easily and cheaply. It must be remembered that cement or concrete posts are made for long continued service and that simply because a certain mold works well is not a sufficient reason for purchasing and using it.

Next to the shape and size of mold we should look for ease of operation. Too many complications are likely to prove to be hindrances to the speed with which posts may be turned out. The simple mold almost always proves to be best, providing it has sufficient strength.

Care of Molds.—Before the molds are used they should be well coated with some kind of heavy oil. Crude petroleum is perhaps the best and cheapest material for this purpose. In case the petroleum cannot be obtained, a good oily mixture may be made by stirring about two pounds of axle grease into a gallon of gasoline. This mixture is applied to the molds with a brush. The gasoline evaporates, leaving a thin coat of axle grease spread over the entire surface of the mold. This oily mixture should be applied to

the outside as well as to the inside of the mold, which makes it impossible for any of the material to cling to it. With the iron molds, the oil prevents rusting. In case the molds are made of wood, the oil helps to keep out the moisture, thus preventing shrinking and swelling, and also making them easier to keep clean.

As soon as the mold is removed from the post all material sticking to it should be scraped off and the inside surface covered with a thin coating of oil. In case tamped posts are being made, the oil need not be applied oftener than once for ten or twelve posts; but with poured posts, the oil should be applied each time the mold is removed. Great care should be taken not to allow the molds to become bruised or dented, as it not only causes the posts to have a bad appearance, but allows the mixture to adhere to the uneven spots; thus a great deal of unnecessary trouble is experienced in removing the posts from the molds.

If the molds are not to be used for a time, they should be thoroughly scraped and oiled, inside and out, and carefully laid away. When it is understood that the speed of operation and the value of the posts depend largely upon the condition of the molds, the importance of properly caring for them will be readily understood.

REINFORCEMENT.

Cement and concrete work has the property of resisting great crushing stresses, but when subjected to tensile stress, the best of it breaks very easily.

For this reason it becomes necessary to put some material possessing great tensile strength into the post, in order that the full crushing strength of the cement or concrete may be utilized. Iron is the most satisfactory material from which to make the reinforcement.

The reinforcement should be placed in the post as near the corner as possible. This places it as far as possible from the neutral axis, thus giving it the greatest advantage in strengthening the post. In order that the reinforcements may be properly held and protected by the cement, it is a good plan to place it from ⅜ to ¾ inch in from each side. This insures a good, firm grip of the cement upon the reinforcement.

The material used for reinforcement should be strong, light, and rough enough to permit the mixture to get a firm grip upon it. It should be very rigid, with little or no tendency to spring or stretch.

A great many special reinforcements are now being made, but the farmer should see to it that the reinforcement which he is to use is reliable, rigid, and easily secured.

The experiment showed that ordinary iron or steel wire was cheapest, strongest and easiest to procure. In order to provide a

means by which the cement may cling firmly to the wire, it is best to twist two small wires together instead of using one large one.

If the twisted wire can be bought, cut to the right length and packed in bundles in the same way as bailing wire, it is best to procure it in this way. In case the twisted wire comes in rolls, it becomes necessary to straighten each piece before it can be used. In this case, it is best to purchase common smooth wire of the desired size and twist it on the farm. The twisting is easily done by tieing one end of each wire to the opposite spoke of the fly wheel of some machine; a corn sheller or hand cider mill will serve the purpose very well. By tieing the other ends of the wires to a weight which may drag along upon the ground, from 100 to 200 feet of wire may be twisted in a very few minutes.

In case a small engine is available the twisting becomes still easier. The advantage of the home twisted wire over twisted wire which is bought in rolls, lies in the fact that the former is straight at the end of the twisting process, while the latter is bent and must be straightened.

The cutting of the wire is best accomplished as follows: Set a cold chisel (with the edge up) in a low, rough bench, and at a distance exactly equal to the length of the reinforcement wire from the edge of the chisel, nail a block to the bench. Take a light hammer in the right hand and seize the twisted wire with the left. Then drag the wire over the chisel until the end of it strikes the block, when a light blow directly over the chisel easily cuts the wire. The piece which is cut off is now laid to one side and the end of the main wire is drawn to the block and another piece cut off.

SPECIAL REINFORCEMENT.

Some have suggested that a piece of wood be placed in the center of the post as a reinforcement. This must be considered a failure, as the wood shrinks and expands by differences in moisture conditions. When it absorbs water, it is likely to swell and burst the post, and again when it dries it will shrink away from the cement.

Gas pipe has also been suggested as one of the best materials to use as a reinforcement. In case plenty of strong second hand pipe is at hand, this may be true. As the pipe is placed in the center of the post, it is not in position to act to the best advantage as a reinforcement, and for this reason it should be strong enough to withstand almost all the strain. New pipe would make the posts altogether too expensive.

Crimped wire is also claimed, by some, to be superior to that which has been twisted, but as the pull comes upon the wire there is a tendency to straighten the crimps. When the wires happen to be

near the surface, there is great danger of the post being split by this straightening process.

Band iron and strap iron are also being used as reinforcement. In case the mixture has a good chance to get a grip on the iron, it will probably prove satisfactory, but unless the iron is roughened there is a danger of it slipping.

For very large posts, the twisted steel rods will prove as satisfactory as twisted wire. Smooth rods or smooth wire slip.

CURING THE POSTS.

In order for the cement to become thoroughly cured or "set," water must be supplied to aid in the action. This action goes on for a long time, some authorities estimating the total period at from 15 to 20 years. For the first thirty days the cement should be kept wet if the best results are to be expected. This means that the posts must be kept wet, and the question arises, what is the best system of keeping them in this condition?

The answer is a simple one. The most favorable conditions for conserving the moisture consists in curing the posts in a shed where the wind does not strike them. Under these conditions neither the sun's rays nor the wind have a chance to dry out the posts too rapidly. The only thing that now remains is to keep the posts in a wet condition.

After the posts are placed in an upright position in the curing shed, as described in "Handling the Posts," sprinkle them thoroughly every day. This may be done either by a hose and nozzle in connection with some form of pressure supply tank or by means of a garden sprinkler. In the latter case provision must be made so that the person doing the work may walk upon some structure above the tops of the posts.

The posts should be thoroughly sprinkled every day for at least 30 days.

HANDLING OF POSTS.

In removing the posts from the molds great care must be taken not to allow the posts to sag or crack. A post may be cracked in handling and still be fit for service, but it cannot be considered to be as valuable as an uncracked one.

There are two general methods of removing the posts from the molds.

The first method consists of laying the molds with the posts in them on a level bed of soft sand. The mold is then turned upside down and the post allowed to settle into the sand. The mold is next removed and the post allowed to lay undisturbed for several days. When the post is sufficiently strong it is placed in an upright position to be cured. While this method requires more space it is

perhaps a little better for the posts than the second method.

The second method consists in removing the posts from the molds while in an upright position. The post is then allowed to lean against a wall or some other support. Thus only one handling is necessary. Care should be taken to have the bottom of the post close to the wall, as it is very likely to break if not kept very nearly in an upright position.

After the posts are cured and ready to set they should be moved from the curing shed and hauled to the fence line in a wagon having a strong, rigid bed. The bottom of the bed should be covered with a layer of straw to prevent breakage. Not more than three to four layers of posts should be placed in the wagon, depending upon road conditions. It must be remembered that a five-inch post weighs 100 pounds or more. When this is considered, we see how easy it is to load a wagon and also how sufficient weight may be placed on the posts in the lower layer to cause them to break.

In handling and setting care must be taken not to drop the posts. The weight of the post places unnecessary stress upon the different parts, and in case it is dropped there is great danger of it being cracked or destroyed.

A careless workman can easily do more damage to the posts than his services are worth.

WIRE FASTENERS.

In case of the wood post the method of fastening the wire consists of simply stapling the wire to it. In order to fasten a wire to a cement or concrete post a different system must be used.

With the ordinary wood staple in mind, one inventor has designed a small cast iron socket or staple holder which is placed where it is desired in the face of the post before the cement has hardened. When the post is set in the ground, the wire is fastened to it by simply driving an ordinary staple into the socket. The staples pull out much easier than they do from the wood post. The jar of driving in the staples tends to split and crush the post at the point where the cast staple holder is placed. Moreover, the cost of the staples and holders adds greatly to the expense of the post.

Another system consists of two staples which have the prongs bent to the side. The staples are placed about one-quarter inch apart, with the prongs projecting to the side. The line wire is placed between the two staples and a nail or piece of wire is driven down through the staples, outside of the line wire. As the tips of the staple touch the reinforcement wires, direct electric connections are established between the line wire and the ground at the bottom of

the post. This, it is claimed by the patentee, insures the user against loss of stock by lightning. The system is called the "Double Staple." (See Fig. 5.)

A "single staple" may also be used, but the wire is fastened to the staple by a small "cold shut link," or wire ring. The latter system is not a very strong method of fastening, owing to the ease with which the cold shut links open. (See Fig. 5.)

Perhaps the most common method of fastening wires to cement or concrete posts consists of tieing in the line wire to the post by means of a piece of smaller wire called a "tie wire" (usually No. 14 or No. 15 wire). The single tie consists of wrapping one end of

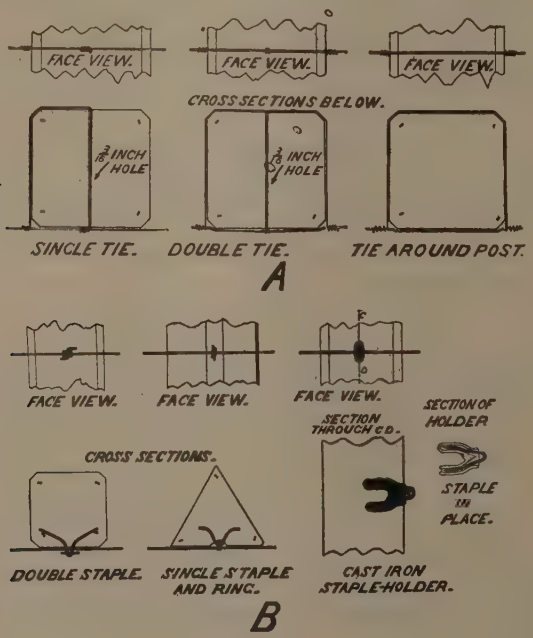

Figure 5.

Different Types of Wire Fasteners.—A, Home made fasteners. B, Commercial Fasteners.

the tie wire three or four times around the line wire, then passing the long end through a hole in the post and bringing it around to the face of the post where it is also wrapped around the line wire. (See Fig. 5.)

The tie around post is much the same as the single tie, except that the tie wire passes around the post instead of through the hole. (See cut.) Neither the single tie or the tie around post are very strong unless the tips of the tie wire are hooked over the body of the tie wire after the wraps have been made. This is known as the "special tie."

The strongest and perhaps the most satisfactory system of tie-

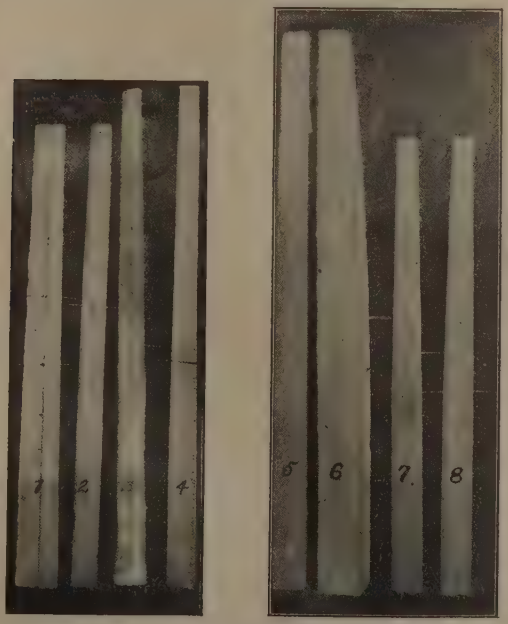

Figure 6.

Different Types of Cement Posts and Wire Fasteners.—1. Triangular post with single staple and ring wire fastener. 2. A square post with double staple fastener. 3. A seven-foot post with cast staple holders. 4. A seven-foot post with tie around post. 5. A 7-inch eight-foot corner post. 6. An 8-inch eight-foot corner post with staples cast in post. 7. A 5-inch tamped post with single tie wire fastener. 8. A 5-inch poured post with double tie wire fastener.

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ing in the wire is the "Double tie." The tie wire is bent into the form of a long staple, straddled over the line wire and both ends passed through a hole in the post. One end is brought to either side and wrapped about the line wire at the face of the post. This system insures a solid fastening and is equal in strength to any ordinary wood post fastening.

The holes in the posts are formed by No. 6 wires being placed in the post while it is soft. These wires are called "Tie Hole Pins." (See cut.) They are removed from the poured post after the cement has set for 24 hours. The pins are removed from the tamped posts immediately before the molds are removed.

The following table shows the comparative holding strength of various wire fasteners, as determined by the tests:

WIRE FASTENERS (See description of same.)	KIND OF POST	No. Lbs. Required to Pull Fastener	REMARKS
Ordinary 1¾ in. staple	New Cedar	425	Ave. of three pulls. Staple was well driven into post.
Single special tie	Cement	520	Ave. of 2 pulls. Fence wire broke.
Double tie	Cement	510	Ave. of 2 pulls. Fence wire broke.
Double staple	Cement	245	Ave. of 3 pulls. Staples pulled.
No. 14 wire plain single tie	Cement	115	Ave. of 2 pulls. The wire untwisted.
No. 14 wire around post	Cement	110	Ave. of 3 pulls. The wire untwisted.
Cast staple holder with ordinary 1¾ in. staple driven into it	Cement	85	Ave. of 2 pulls. Staple pulled out of holder
Cold shut-link in single staple	Cement	83	Link opened in every case,. Ave of 3 pulls.

TAPER OF POSTS.

To obtain the maximum strength with the least amount of material, the cement post must be so shaped as to have its greatest strength at the ground line.

While it is easy to make a post which tapers from the bottom to the top it requires somewhat more material than is necessary and it is smaller at the ground line than at the base. Thus the gradual taper not only uses more material than is necessary, but it reduces the strength at the place where it is most needed.

By making the post of uniform size from the base to the ground line, no material is wasted. The post may then be tapered from the ground line to the top.

Many of the posts which are being made now taper only one-half inch on each side from the base to the top. It has been found that in a 5-inch post which projects 4 feet above the ground, a taper of one inch on each side from the ground line to the top, insures almost equal strength throughout. This design gives more strength with less material than those with the continuous taper.

TESTS OF THE CEMENT USED.

Several tests were conducted to determine the strength of the cement used at different times during the post experiment.

The Cubes and Briquettes were made in the same manner as the posts, *i. e.*, they were kept in the shed and thoroughly wet once a day for 28 days, at which time they were tested.

The following table represents inch Briquettes tested in tension. The figures represent an average of three tests:

SAMPLE NO.	MIXTURE		STRENGTH IN LBS.
	PROPORTION	KIND	
1	1—3	Tamped	172
1	1—3	Poured	186
2	1—3	Tamped	171
2	1—3	Poured	193
3	1—3	Tamped	176
3	1—3	Poured	184
1	1—2—3	Tamped	88
1	1—2—3	Poured	97

Three-inch cubes tested in compression. Figures represent an average of three tests:

SAMPLE NO;	MIXTURE		STRENGTH IN LBS. Per Square Inch.
	PROPORTION	KIND	
1	1—3	Tamped	971
1	1—3	Poured	989
2	1—3	Tamped	970
2	1—3	Poured	982
3	1—3	Tamped	980
3	1—3	Poured	1015
1	1—2—3	Tamped	357
1	1—2—3	Poured	375

PART II.

THE EXPERIMENTS.

These experiments were conducted for the purpose of determining the method of building the best posts at the least cost.

Apparatus.—Various commercial molds of different shapes and construction were secured. In each of these molds several posts were made in order to determine the practicability of the mold; also the best combination of mixtures and reinforcements.

The Farm Mechanics Department designed, built and used a simple home made mold which makes a post of uniform size from the base to the ground line with a rapid taper from the ground line to the top. (See Fig. 4.) The department also designed and built a simple home made concrete mixer which was used in the experiment. (See Fig. 1.)

A shed which was closed on all sides with a sliding door on the east was used as the work and curing room.

TABLE NO. 1—Poured Posts.

Size, 5x5 inches from base to ground line, tapering to 3x3 inches at top. Length, 6 feet 6 inches. Cured weight, 115 to 120 pounds. Mixture, 1 part cement and 3 parts sand, by measure. Cost for cement per post, 16.2 cents; sand, 3.7 cents. Fort cost of reinforcement, see table.

REINFORCEMENT			TEST			COST	REMARKS
KIND OF WIRE	WEIGHT PER POST	COST PER POST	FIRST CRACK IN LBS.	FINAL BREAK IN LBS.	LOCATION OF BREAKS ABOVE OR BELOW GROUND LINE.	COST OF MATERIAL IN POST	NEW WIRE IS FIGURED AT 4C PER LB. AND OLD WIRE AT 2C PER LB.
No. 10, 4 twisted strands of 2 wires.	2¼ lbs	10c	250	307	Ground Line Ground Line 1 in. below.	29.9c	Wires broke they did not slip.
No. 10, 8 strands crimped.	2½ lbs	10c	243	254	6 in. below, Ground Line 3 in. above	29.9c	All wires slipped slightly before breaking.
No. 6, 4 long wires hooked at ends.	2⅔ lbs	10.6c	137	232	6 in. above Ground Line 1 in. below	30.5c	All wires slipped wires not crimped.
New Barbed 4 long strands	1⅔ lbs	6.6c	148	188	Ground Line 2 in. below 2 in. below	26.5c	Post 130 days old wires broke.
Old Barbed 4 long strands.	1⅔ lbs	3.3c	143	158	Ground Line Ground Line 4 in. below	23.2c	Wires broke.
Old Barbed 4 long and 2 short.	2 lbs	4.0c	167	200	10 in. above 4 in. above 16 in. above	28.9c	Mixture gave way above extra wires.
Old Barbed 4 long and 4 short.	2¾ lbs	5.5c	148	229	18 in. above 18 in. above 20 in. above	25.4c	All wires broke above extra wires.
No. 10, twisted 4 long and 2 short.	3 lbs	12c	128	290	1 in. below 3 in. below 5 in. below	31.9c	Extra wires did no good.

Materials.—The sand and gravel used was clean and sharp, with all sizes of grains varying from small to large. There was a very small percentage of mica in the sand, which was objectionable. One brand of Portland cement was used for making all posts.

A total of 238 line posts and 8 corner posts were built and tested during the experiment, the records of which are found in the following tables:

TABLE NO. 2—Tamped Posts.

These posts are of the same size and composition as those in Table No. 1, excepting that they are tamped instead of poured.

REINFORCEMENT			TEST			COST	REMARKS
Kind of Wire	Weight Per Post Lbs.	Cost Per Post	First Crack in Lbs.	Final Break in Lbs.	Location of Break Above or Below Ground Line	Cost of Materials in Post	New Wire is Figured at 4c Per Lb. and Old Wire at 2c Per Lb.
No. 10, 4 twisted strands of 2 wires	2⅛	10.0c	162	240	1 in. above 15 in. above Ground Line	29.9c	Mixture broke wires did not slip or break
No. 10, 8 strands crimped	2½	10.0c	197	263	Ground Line 2 in. above 10 in. above	29.9c	Wires slipped
No. 10, twisted 4 long and 2 short	3	12.0c	130	160	30 in. above 30 in. above 30 in. above	31.9c	Mixture broke extra wires did no good
No. 6, 4 long hooked at ends	2⅝	10.6c	133	184	10 in. from top Ground Line Ground Line	30.5c	Straight wires, all wires slipped
New Barbed 4 long strands	1⅝	6.6c	70	123	Ground Line 2 in. above Ground Line	26.5c	Wires broke
Old Barbed 4 long strands	1⅝	3.3c	98	128	Ground Line Ground Line Ground Line	23.2c	Wires broke
New Barbed 4 long and 2 short	2	8.0c	83	198	Ground Line 6 in. below 1 in. above	27.9c	Wires broke
No. 15, 4 strands of 3 each twisted	1⅛	4.5c	82	125	Ground Line 7 in. above 3 in. above	23.6c	All wires broke did not slip

The Test.—In making the test, the posts were placed under as nearly fence conditions as possible. All line posts were set and firmly tamped into the ground so that 4 feet and one inch projected above the surface. By means of a wire, a dynamometer was attached to the post exactly 4 feet from the surface, as shown in Fig. 7. A steadily increasing force was applied to the dynamometer by means of a block and tackle, until the first visible crack appeared in the post when a reading was made. The force was then increased until the post gave way completely when the final reading was made.

TABLE NO. 3—Poured Posts.

Size, 5x5 inches from base to ground line, tapering to 3x3 inches at top. Length 6 feet 6 inches. Cured weight, 110 to 115 pounds. Mixture, 1 part cement and 4 parts sand, by measure. Cost for cement per post, 22 pounds, 13.2 cents; sand, 1 cubic foot, 3.7 cents. For cost of reinforcement, see table below.

REINFORCEMENT			TEST			COST	REMARKS
Kind of Wire	Weight Per Post Lbs.	Cost Per Post	First Crack in Lbs.	Final Break in Lbs.	Location of Break Above or Below Ground Line	Cost of Material in Post	New Wire is Figured at 4c per Lb. and Old Wire at 2c per Lb.
4 strands or 2 wires twisted No. 10	2½	10.0c	147	222	28 in. above 30 in. above 42 in. above	26.9c	Mixture gave way, wires not well placed.
4 long and 2 short twisted strands No. 10	3	12.0c	237	322	8 in. below 7 in. below 11 in. below	28.9c	Mixture and wires about equal strength
4 long straight wires hooked at ends No. 6	2⅝	10.6c	170	222	Ground Line 3 in. below	27.5c	Wires slipped
4 long old barbed wires	1⅝	3.3c	70	95	Ground Line 3 in. below 5 in. below	20.2c	Wires broke, they were poorly placed.
4 long and 2 short old barbed wire	2	4.0c	98	127	18 in. above 20 in. above 13 in. above	20.9c	Wires broke. Poor wire.
4 long and 2 short new barbed wire	2	8.0c	138	172	20 in. above 19 in. above 12 in. above	24.9c	Wires well placed. Cement broke.
4 long strands of 3 twisted wires No. 14	1⅝	6.6c	68	105	Ground Line Ground Line 3 in. below	23.5c	Wires broke.

Figure 7.

Method Which Was Used in Testing All Line Posts.—The distance from the ground line to the point at which the hitch was made is four feet. The dynamometer records the exact number of pounds of pull required to break the post.

In making the posts, enough of the mixture was provided for the construction of three posts at once. The three were cured alike, for 60 days and were tested at the same time. The tables show the average results of the test on the three posts as one.

In the reinforcement the short wires mentioned are two feet long and are placed in the post so the top extends about 12 inches above the ground line and the bottom about 12 inches below. One of these extra wires is placed in the face side of the post and the other in the back, so that they help to bear the strains on the post.

In case of four extra wires, one is placed in each corner of the post with the other reinforcement wires.

Cost of Materials.—In figuring cost of materials the following prices were used:

Sand and gravel, $1.00 per cubic yard.
Cement, 60 cents per sack.
New reinforcement, 4 cents per pound.
Old barbed wire, 2 cents per pound.

TABLE NO. 4—Tamped Posts.

These posts are of the same size and composition as those in Table No. 3, excepting they are tamped instead of poured.

REINFORCEMENT			TEST			COST	REMARKS
Kind of Wire	Weight Per Post in Lbs.	Cost Per Post	First Crack in Lbs.	Final Break in Lbs.	Location of Break Above or Below Ground Line	Cost of Material in Post	New Wire is Figured at 4c per Lb. and Old Wire at 2c per Lb.
4 long strands of 2 wires twisted, No. 10	2½	10.0c	122	192	Ground Line Ground Line 2 in. above	26.9c	Wires broke
4 long straight strands, No. 6	2⅔	10.6c	103	162	Ground Line Ground Line	27.5c	Wires slipped
4 long strands old barbed wire	1⅔	3.3c	117	137	14 in. above 30 in. above Ground Line	20.2c	Wires broke
4 long and 2 short old barbed wire.	2	4.0c	122	142	12 in. above 12 in. above 13 in. above	20.9c	Wires broke
4 long new barbed wire	1⅔	6.6c	140	160	Ground Line Ground Line Ground Line	23.5c	Wires broke
4 long and 2 short new barbed wire.	2	8.0c	80	170	11 in. below 16 in. above 13 in. above	24.9c	Wires not well placed
4 long and 4 short old barbed wire.	2¾	5.5c	112	196	18 in. above 8 in. below 24 in. above	22.4c	One post broke 8 in. below also 23 in. above Gr. L.

TABLE NO. 5—Poured Posts.

Size, 5x5 inches from base to ground line, tapering to 3x3 inches at top. Length, 6 feet 6 inches. Cured weight, 110 to 112 pounds. Mixture, 1 part cement and 5 parts sand, by measure. Cost for cement per post, 17 pounds, 10.2 cents; sand, 1 cubic foot, 3.7 cents. For cost of reinforcement, see table below.

REINFORCEMENT			TEST			COST	REMARKS
Kind of Wire	Weight Per Post Lbs.	Cost Per Post	First Crack in Lbs.	Final Break in Lbs.	Location of Break Above or Below Ground Line	Cost of Material in Post	New Wire is Figured at 4c per Lb. and Old Wire at 2c per Lb.
4 strands 2 twisted wires, No. 10	2½	10.0c	197	235	2 in. below Ground Line 4 in. above	23.9c	Mixture broke. Reinforcement wires poorly placed
4 long and 2 short twisted strands No. 10	3	12.0c	197	220	3 in. below 5 in. below Ground Line	25.9c	Extra wires did no good. Mixture broke.
4 long strands old barbed wire	1⅔	3.3c	95	113	Lost 1 in. below 7 in. below	17.2c	Wires broke, not well placed.
4 long and 2 short old barbed wire	2	4.0c	97	137	4 in. above 10 in. above 7 in. below	17.9c	Mixture and wires about equal strength
4 long strands new barbed wire	1⅔	6.6c	78	123	2 in. below 16 in. above 4 in. above	20.5c	Mixture and wires about equal strength.
4 long and 2 short new barbed wire	2	8.0c	75	140	10 in. above 8 in. above 18 in. above	21.9c	Wires broke
4 long strands of 3 twisted wires No. 14.	1⅔	6.6c	103	130	Ground Line 2 in. below 3 in. below	20.5c	Wires broke
4 long and 2 short strands 3 twisted No. 14	2	8.0c	103	175	14 in. above 13 in. above 14 in. above	21.9c	Wires and mixture about equal strength

TABLE NO. 6—Poured Posts.

Size, 4x4 inches at base, tapering to 3x3 inches at top. Length, 6 feet 6 inches. Cured weight, 80 pounds. Mixture, 1 part cement and 4 parts sand, by measure. Cost for cement, 13.5 pounds, 8.1 cents; sand, ⅔ cubic foot, 2.5 cents. For cost of reinforcement, see table below.

REINFORCEMENT			TEST			COST	REMARKS
Kind of Wire	Weight Per Post Lbs.	Cost Per Post	First Crack in Lbs.	Final Break in Lbs.	Location of Break Above or Below Ground Line	Cost of Materials in Post	New Wire is Figured at 4c per Lb. and Old Wire at 2c per Lb.
4 strands of 2 twisted wires No. 10	2½	10.0c	80	168	2 in. below Ground Line Ground Line	20.6c	Mixture broke on two posts, wires broke on the other
4 long strands old barbed wire	1⅔	3.3c	50	65	5 in. above Ground Line 3 in. above	13.9c	Wires broke
4 long strands new barbed wire	1⅔	6.6c	82	88	Ground Line 6 in. below Ground Line	17.2c	Wires broke on one and mixture on two posts.
4 long strands of 3 twisted wires No. 14.	1⅔	6.6c	58	62	2 in. below Ground Line 5 in. above	17.2c	Wires broke, Mixture broke on one post.

TABLE NO. 7—Tamped Posts.

These posts are of the same size and composition as those in Table No. 5, excepting they are tamped instead of poured.

REINFORCEMENT			TEST			COST	REMARKS
Kind of Wire	Weight Per Post Lbs.	Cost Per Post	First Crack in Lbs.	Final Break in Lbs.	Location of Break Above or Below Ground Line	Cost of Materials in Post	New Wire is Figured at 4c per Lb. and Old Wire at 2c per Lb.
4 strands of 2 twisted wires No. 10	2½	10.0c	75	97	6 in. below 8 in. above 8 in. below	23.9c	Mixture gave way, posts split.
4 long and 2 short twisted strands No.10	3	12.0c	73	98	2 in. below 3 in. below	25.9c	Mixture gave way, posts split.
4 long strands old barbed wire	1⅝	3.3c	88	117	4 in. below 2 in. above Ground Line	17.2c	Wires broke
4 long and 2 short old barbed wire	2	4.0c	77	113	13 in. above 15 in. above Ground Line	17.9c	Mixture and wire about equal, one wire poorly placed
4 long strands new barbed wire	1⅝	6.6c	60	108	1 in. below Ground Line Ground Line	20.5c	Mixture and wires nearly equal strength.
4 long and 2 short new barbed wire	2	8.0c	47	103	12 in. above 16 in. above Ground Line	21.9c	Wires in 2 posts poorly placed.

TABLE NO. 8—Poured Posts.

Size, 4x4 inches at base, tapering to 3x3 inches at top. Length, 6 feet 6 inches. Cured weight, 80 pounds. Mixture, 1 part cement and 3 parts sand, by measure. Cost for cement, 18 pounds, 10.8 cents; sand, ⅔ cubic foot, 2.5 cents. For cost of reinforcement, see table below.

REINFORCEMENT			TEST			COST	REMARKS
Kind of Wire	Weight Per Post Lbs.	Cost Per Post	First Crack in Lbs.	Final Break in Lbs.	Location of Break Above or Below Ground Line	Cost of Materials in Post	New Wire is Figured at 4c per Lb. and Old Wire at 2c per Lb.
4 strands of 2 twisted wire No. 10	2½	10.0c	162	183	Ground Line Ground Line Ground Line	23.3c	Mixture and wires about equal strength.
4 long strands old barbed wire	1⅝	3.3c	73	108	2 in. below 2 in. above 2 in. below	16.6c	Wires broke
4 long strands new barbed wire.	1⅝	6.6c	82	105	4 in. below 2 in. above Ground Line	19.9c	Wires broke
4 long strands of 3 twisted No. 14	1⅝	6.6c	78	102	Ground Line Ground Line Ground Line	19.9c	Wires broke
4 long, 2 short strands of 3 twisted No.14	2	8.0c	162	185	10 in. above 12 in. above 4 in. below	21.3c	Wires broke
(Specials) 4 long twisted strands No.9.	2¾	11.0c 11.0c	140 cracked	140 125	Ground Line Ground Line	24.3c 24.3c	These posts were secured from the manufactu'r.

TABLE NO. 9—Poured Posts.

Size, 5x5 inches from base to ground line, tapering to 3x3 inches at top. Length, 6 feet 6 inches. Cured weight, 115 to 120 pounds. Mixture, 1 part cement 3 parts sand and 3 parts gravel, by measure. Cost of cement per post, 14 pounds, 8.4 cents; sand and gravel, 1 cubic foot, 3.7 cents. For cost of reinforcement, see table below.

REINFORCEMENT			TEST			COST	REMARKS
Kind of Wire	Weight Per Post Lbs.	Cost Per Post	First Crack in Lbs.	Final Break in Lbs.	Location of Break Above or Below Ground Line	Cost of Materials in Post	New Wire is Figured at 4c per Lb. and Old Wire at 2c per Lb.
4 strands of 2 wires twisted No. 10	2¼	10.0c	177	218	Ground line Ground line 4 in. below	22.1c	Wires broke on 2 and mixture broke on one.
4 long and 2 short twisted strands No. 10	3	12.0c	188	330	4 in. above 12 in. above 4 in. below	24.1c	Wires broke
4 long strands old barbed wire	1⅔	3.3c	88	110	Ground line Ground line Ground line	15.4c	Wires broke
4 long and 2 short old barbed wire	2	4.0c	70	118	20 in. above 24 in. above 15 in. above	16.1c	Wires broke, not well placed.
4 long strands new barbed wire	1⅔	6.6c	103	143	4 in. below Ground line Ground line	18.7c	Wires broke
4 long and 2 short new barbed wire	2	8.0c	115	123	Ground line 3 in. above 10 in. above	20.1c	Wires broke
4 long strands of 3 twisted wires, No. 14	1⅔	6.6c	102	123	Ground line 27 in. above Ground line	18.7c	Wires broke
4 long 2 short strands of 3 twisted No. 14	2	8.0c	85	143	Ground line 7 in. below 4 in. below	20.1c	Mixture broke on two and wires broke on one.

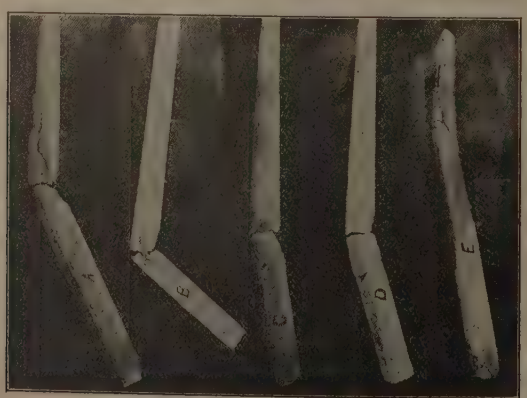

Figure 8.

A few types of broken posts showing: (A) The splitting off of the tamped post. (B) The bursting due to the buckling of the tube of a commercial truss. (C) A post in which mixture and reinforcement were about equal. (D) A post in which smooth wire reinforcement was used, the wires slipped, thus allowing the post to bend. (E) Post removed from mold too soon.

TABLE NO. 10—Poured Posts.

Made in sheet iron mold, which makes a post round on one side and flat on the other. Size 5x5 inches at base, tapering to 3x3 inches at top. Length, 7 feet. Cured weight, 75 to 80 pounds. Mixture, 1 part cement and 3 parts sand by measure. Cost for cement per post, 18 pounds, 10.8 cents. Sand, ⅔ cubic foot, 2.5 cents. For cost of reinforcement, see table below. The reinforcements in this post are supposed to be placed in three places, two next to the flat side and one on the oval side of the post. This makes the flat side stronger. In the test, one post of the three was pulled away from the flat side toward the round side, and two from the round side toward the flat side.

Those marked (a) were pulled away from flat side, and (b) towards it.

REINFORCEMENT			TEST			COST	REMARKS
Kind of Wire	Weight Per Post Lbs.	Cost Per Post	First Crack in Lbs.	Final Break in Lbs.	Location of Break Above or Below Ground Line	Cost of Materials in Post	New wire is Figured at 4c per Lb. and Old Wire at 2c per Lb.
3 long No. 19 ⅝ in. band iron	2¼	9.0c	135 (a) 120(b)	190(a) 125(b)	Ground line Ground line	22.3c	Posts from manufacturer, band iron broke.
3 long strands of 2 wires twisted No.10	1⅞	7.5c	85(b) 95(b) 125(a)	125(b) 135(b) 180(a)	Ground line 3 in. below Ground line	21.8c	Wires broke
3 long strands old barbed wire	1¼	2.5c	70(b) 65(b) 70(a)	70(b) 80(b) 105(a)	Ground line Ground line Ground line	15.8c	Wires broke
3 long and 3 short old barbed wire	2	4.0c	100(b) 120(a) 100(b)	115(b) 155(a) 110(b)	18 in. above 12 in. above 20 in. above	17.3c	Wires broke above extras
4 long strands old barbed wire	1⅔	3.3c	crack'd 85(a) 125(b)	120(b) 125(a) 155(b)	2 in. above 1 in. below Ground line	16.6c	Wires broke
4 long and 4 short old barbed wire	2¾	5.5c	120(b) 115(a) 120(b)	165(b) 120(a) 160(b)	15 in. above 14 in. above 7 in. above	18.8c	Mixture broke
4 long strands, 2 each, twisted No. 10	2½	10.0c	130(b) 180(b) 150(a)	175(b) 230(b) 200(a)	Ground line Ground line Ground line	23.3c	Mixture broke

The last 3 sets of posts contained 4 reinforcements instead of 3. It will be noticed that the one extra wire made a great difference in the strength of these posts; they are more nearly equal strength from both directions.

AMOUNT OF LABOR REQUIRED FOR MAKING POSTS.

No definite statements can be made as to the amount of time required to make a cement or concrete fence post. The amount of time will vary with conditions, handiness of materials, methods of mixing, etc. According to data obtained in the experiment, two men mixing by hand, with everything reasonably handy, can make from three to five 5-inch poured line posts per hour. Figuring labor at $2.00 per day, ten hours for each man, the cost for making a post would amount to about 10 cents each. Three men with a small home made mixer and a two-horse-power gasoline engine for driving it would be able to make at least twice as many posts as two men working by hand and the cost for making would be very much less.

TABLE NO. 11—Poured Posts (Triangular).

These are triangular posts made in triangular sheet iron molds. Size 7 inches on each side at the bottom, tapering to 5 inches on each side at the top. Length, 6 feet 6 inches. Cured weight, 85 pounds. Mixture, 1 part cement and 3 parts sand, by measure. Cost for cement per post, 19 pounds, 11.4 cents. Sand, ⅔ cubic feet, 2.5 cents. For cost of reinforcement, see table below. In the test, one post of the three was pulled away from the flat side towards the opposite corner and is marked (a); the other two were pulled from one corner towards the opposite flat side and are marked (b).

REINFORCEMENT			TEST			COST	REMARKS
Kind of Wire	Weight per Post Lbs.	Cost Per Post	First Crack in Lbs.	Final Break in Lbs.	Location of Break Above or Below Ground Line	Cost of Materials in Post	
3 long strands new barbed wire	1¼	5.0c	65(b) 90(a) 70(a)	100(b) 90(a) 105(a)	2 in. below 2 in. above 2 in. below	18.9c	Wire broke Mixture crushed Mixture crushed
3 long and 3 short old barbed wire	1¾	3.5c	45(b) 35(b) 30(a)	50(b) 55(b) 100(a)	15 in. above 15 in. above 15 in. above	14 9c	Wires broke Wires broke Mixture crushed
6 long old barbed wires 2 in each corner	2¼	4.5c	80(b) 110(b) 130(a)	120(b) 190(b) 130(a)	2 in. above 2 in. below 2 in. below	15.9c	Wires broke Wires broke Mixture crushed
3 long No. 14 3 strands twisted	1¼	2.5c	70(b) 85 a)	90(b) 145(a)	4 in. above 4 in. below	13.9c	Wires broke Mixture crushed
4 long new barbed wires*	1⅜	6.6c	110(b) 75(a)	135(b) 85(a)	Ground line 6 in. above	18.0c	Mixture split Mixture crushed
4 long No. 14 3 strands twisted	1⅔	6.6c	165(b) 160 b) 115(a)	175(b) 180(b) 140(a)	Ground line Ground line Ground line	18.0c	Mixture crushed Wires broke Mixture crushed
4 long No. 15 3 strands twisted	1⅛	4.5c	130(b) 130(b) 105(a)	150(b) 175(b) 105(a)	Ground line Ground line 1 in. above	15.9c	Wires broke Wires broke Mixture crushed

THE EFFECT OF ALKALI ON CEMENT AND CONCRETE POSTS.

It has been found that some soils contain an excessive amount of alkali, which has a tendency to destroy concrete work. While no experimental work has been done to test the effect of such soils upon cement or concrete posts, it has been conclusively proven that cement drain and sewer tiles which come in contact with water which has percolated through these alkali soils are soon destroyed.

While it might be possible that the action on cement or concrte posts would be slower than in case of the tiles, it is probable that the posts would eventually be destroyed.

For further information in regard to the effect of alkali on cement construction see Bulletin No. 69 of the Montana Agricultural College Experiment Station, and Bulletin No. 132, Agricultural Experiment Station of the Colorado Agricultural College.

*Where 4 wires are used for reinforcement, the extra wire is placed in the corner opposite to the side on which the fence wires are fastened.

TABLE NO. 12—Poured Posts.

These posts were made in special sheet iron lined wood molds put out by a certain manufacturer. The reinforcement recommended for these posts is a special trussed tube, which is sold by the manufacturer at 15 cents each at the factory. The results of the test on three posts in which this truss was used is shown below in connection with other similar posts with wire reinforcement. Size of post, 3½x4½ inches at base, tapering to 3½x3½ inches at the top. Length, 6 feet 6 inches. Cured weight, 80 pounds. Mixture, 1 part cement and 3 parts sand, by measure. Cost of cement per post, 18 pounds, 10.8 cents. Sand, ⅔ cubic foot, 2.5 cents. For cost of reinforcement, see table below.

REINFORCEMENT			TEST			COST	REMARKS
Kind of Wire	Weight Per Post L.bs.	Cost Per Post	First Crack in L.bs.	Final Break in L.bs.	Location of Break Above or Below Ground Line	Cost of Material in Post	New Wire is Figured at 4c per L.b. and Old Wire at 2c per L.b.
Special Commercial Trussed Tube	3. 6-oz.	15.0c	105	150	Ground line Ground line Ground line	28.8c	In every case trussed tube bent caused post to crack.
4 long strands new barbed wire	1⅔	6.6c	130	137	Ground line Ground line Ground line	19.9c	Wires broke, Wires poorly placed in one post.
4 long strands 3 twisted No; 14 wires	1⅔	6.6c	75	107	1 in. below 1 in. below Ground line	19.9c	Wires broke, Wires poorly placed in one post.
4 strands of 2 wires twisted No. 10	2½	10.0c	110	160	3 in. below Ground line 2 in. below	23.8c	One wire broke in each post.

Figure 9.

A 7-inch corner post braced with a 2-inch gas pipe 14 feet long; 5-inch brace post. The exact number of pounds of pull exerted by each of the two fences is recorded by the dynamometer shown under the arrow.

THE THREE-CORNERED POST.

The three-cornered post, which is advocated to some extent, does not have as many points in its favor as it may seem. In the first place an equal amount of reinforcement in each corner of the post cannot make a post of equal strength from two opposite directions. If a force is brought to bear against one of the flat sides of the post towards the opposite corner, the material in the corner will crush long before the wires will break on the side from which

Figure 10.

The post shown in Fig. 9 after the test. Two-fifths of the pressure is exterted above the brace and three-fifths below.

the force is exerted. On the other hand, if a force is brought to bear against one corner of the post towards the opposite flat side, the single reinforcement in the corner will break before the mixture has begun to crush on the flat side.

An extra reinforcement in the corner on which the force is exerted towards the opposite flat side will make it practically as

strong as the flat side. But when the force is again applied to the flat side towards the single corner which is doubly reinforced, the mixture in the corner gives way too soon and it is no better than with but a single reinforcement.

TABLE NO. 13—Corner Posts.

Size, 8x8 inches from base to ground line, tapering to 5x5 inches at top. Length, 8 feet. Cured weight, 360 pounds. Mixture, 1 part cement, 2 parts sand, and 3 parts of gravel, by measure. Cured 90 days. Cost for cement per post, 51 pounds, 30.6 cents; sand and gravel, 3 cubic feet, 11.1 cents. For cost of reinforcement, see table below. Test shows pull exerted in pounds as by each of two fences pulling at right angles.

REINFORCEMENT			TYPE	TEST			COST	REMARKS
Kind of Reinforcement	Weight Per Post Lbs.	Cost Per Post	Poured or tamped	First Crack in Lbs.	Final Break in Lbs.	Location of Break	Cost of Material per Post	All reinforcements figured at 4c Lb. excepting old barbed wire at 2c.
2-8 ft. and 2-5 ft. pieces ½ in. rod on tension side	16	64c	poured	7200	8500	at brace	$1.057	Short wires extended from below ground line to above brace line
Same as above	16	64c	tamped	5050	5600	at brace	1.057	Short wires extended from below ground line to above brace line
14 strands old barbed wire on tension side.	8	16c	tamped	6300	7300	at brace	.577	Mixture broke
Same as above	8	16c	poured	5900	7400	at brace	.577	Mixture broke
10 twisted strands No. 10 on tension side	8	32c	tamped	5400	7300	4 in. below brace	.737	Mixture broke
Same as above	8	32c	poured	6300	6650	4 in. above brace	.737	Mixture broke

Size, 7x7 inches at base, tapering to 5x5 inches at top. Length, 8 feet. Cured weight, 250 pounds. Mixture, 1 part cement, 2 parts sand and three parts gravel, by measure. Cured 90 days. Cost of cement per post, 36 pounds, 21.6 cents; sand and gravel, 2 cubic feet, 7.4 cents. Fort cost of reinforcement, see table below.

REINFORCEMENT			TYPE	TEST			COST	REMARKS
Kind of Reinforcement	Weight Per Post Lbs.	Cost Per Post	Poured or tamped	First Crack in Lbs.	Final Break in Lbs.	Location of Break	Cost of Material Per Post	All reinforcements figured at 4c Lb. excepting old barbed wire at 2c.
8 strands old barbed wire 2 in each corner	4½	9c 2c lb.	poured	2700	3600	at braces	$ .38	Mixture broke
8 strands new barbed wire 2 in each corner	4½	18c 4c lb.	poured	3225	4050	at braces	.47	Mixture broke

HOLLOW POSTS.

It has been suggested that the cement and concrete posts should be made hollow. The hollow post would require less mixture and it would also be lighter. As the material in the center of the post does not have a good opportunity to act to the best advantage in compression, it is argued that the strength of the hollow post would be nearly as great as that of the solid post.

In case time is of little value it would probably prove more economical to build hollow posts. As the amount of reinforcement is not affected by the change from the solid to the hollow post, only the saving in cement, sand and gravel need be considered. It is an easy matter to compute the saving accomplished by the making of hollow posts, and then by knowing the cost of labor, the economy of building them may soon be calculated. With cement at 55 cents per sack and sand at $1.00 per yard, one cubic foot of 1 to 4 mixture costs 18 cents. If a 1½ inch hole were to be left in the center of a post 7 feet long about 1½ cents' worth of material would be saved. With labor at 15 cents per hour, 6 minutes might be given to the extra work of making the post with the hollow core.

In case of alkali soils the hollow center gives additional exposed surface upon which the alkali may act. In a 4-inch square post with a 1½ inch core, the extra surface amounts to about 28 per cent. of the original lateral surface.

Finally there is a serious question as to the relative strength and durability of the hollow post as compared with the solid one.

CORNER POSTS AND GATE POSTS.

In the building of a fence with cement or concrete posts, the corner and gate posts must be especially strong, so as to prevent the pull of the wires coming upon the line posts. All the pull of the wires should be borne by the corner or gate posts. With this in mind the designer should aim not only to build a very strong post, but the system of bracing should receive special attention.

As the cement posts are not as strong as wood posts, we cannot use the same bracing systems, which are so commonly in use in wood post fence construction. It has been found advisable to place the brace so that it supports the post at a point very little, if any, above the middle of the post. For the reason that the posts are strong in compression, but do not stand as much pull as wood posts, it proves advisable to place the brace against the brace post at least one foot below the ground line; thus the post distributes the pressure at the end of the brace against an area of ground equal to the surface covered on the opposite side of the post.

There should be several wires connecting the brace post and the corner or gate post together. These wires should be placed under

the ground at a depth of about one foot. By having these wires tight the corner post cannot move unless the brace post moves, and as this is securely fastened to it, the whole becomes a unit, offering a rigid resistance to the pull of the fence.

In case of a corner post, the wires may be fastened by wrapping them around it, but the most satisfactory way is to cast wire staples in the post. These staples should extend into the post far enough to be wrapped around one or more of the reinforcement wires.

The hinges for gates may also be cast in the posts when it is desired to do so.

Corner and gate posts are usually reinforced in the same way as line posts. It is unnecessary, however, to place reinforcement wires on the inner sides of the corner posts, as the outer sides bear almost all of the tension.

With the tapered posts, it is desirable to construct the face sides straight; this brings all of the taper on the other two sides. Small lugs or shoulders should be cast on each brace side of the post, against which the brace is placed.

The ordinary five-inch line post proves to be strong enough to act as a brace post for an eight-inch corner post.

The following table gives a summary of breaking strength and cost of materials of some of the best poured posts, which were made and tested in this experiment.

MIXTURE	DESCRIPTION	REINFORCEMENT								
		4 Long No. 10 Twisted	4 long 2 short No. 10 twisted.	4 long New Barbed Wire	4 long Old Barbed Wire	4 long 2 short new barbed	4 long 2 short Old Barbed	3 long No.19 5/8 in.band iron	4 long 4 short Old Barbed	6 long Old Barbed
1 to 3	Ground line 5x5 top 3x3	307 lbs. 29.9c	290 lbs. 31.9c	188 lbs. 26.5c	158 lbs. 23.2c	none none	200 lbs. 23.9c			
1 to 4	Ground line 5x5 top 3x3	222 lbs. 26.9c	322 lbs. 28.9c	none none	95 lbs. 20.2c	172 lbs. 24.9c	127 lbs. 20.9c			
1 to 5	Ground line 5x5 top 3x3	235 lbs. 23.9c	220 lbs. 25.9c	123 lbs. 20.5c	113 lbs. 17.2c	140 lbs. 21.9c	137 lbs. 17.9c			
1 to 3	Base 4x4 top 3x3	183 lbs. 23.3c	none none	105 lbs. 19.9c	108 lbs. 16.6c					
1 to 4	Base 4x4 top 3x3	168 lbs. 20.6c	none none	88 lbs. 17.2c	65 lbs. 13.9c					
1 to 3-3	Ground line 5x5 top 3x3	218 lbs. 22.1c	230 lbs. 24.1c	143 lbs. 18.7c	110 lbs. 15.4c	123 lbs. 20.1c	118 lbs. 16.1c			
1 to 3	Base 5x5 top 3x3 horse shoe shape	202 lbs. 23.3c			133 lbs. 16.6c			157 lbs. 22.3c	148 lbs. 18.8c	
1 to 3	Triangular Base 7x7 top 5x5			110 lbs. 18.0c						147 lbs. 15.9c

Strength of Cement posts compared to new wood posts tested under like conditions.

KIND OF POST	SIZE OF POST	BREAKING STRENGTH	REMARKS
(1) Best cement post tested	5x5 in. at ground line tapering to 3x3 in. at top	av. of three 322 lbs.	
(2) Cement	Same as above	av. of three 307 lbs.	
(3) Cement	4x4 in. at base tapering to 3x3 in. at top	av. of three 185 lbs.	The post was 3.6x 3.6 in. at ground
(4) Split cedar (new)	3.6x3.6 in. at ground line	av. of three 613 lbs.	Same size at ground as No. 3 above
White pine (new)	4x4 in. at ground line	2000 lbs.	
Red spruce (new)	4½x4½ in. at ground line	2400 lbs.	
Red spruce (new)	5x5 in. at ground line	3350 lbs.	

CONCLUSIONS.

Poured posts are easier to make than tamped ones. They are somewhat more expensive because one mold will make but one poured post per day, while the same mold may be used for making as many tamped posts as the builder can mix and tamp in the same time.

According to the tests made poured posts are a little over 25 per cent stronger than tamped ones of the same size, mixture and reinforcement.

Poured posts are not so porous as the tamped ones and are therefore more nearly water proof, thus making them better able to withstand the action of frost and alkali.

The poured post is enough better in every respect to justify its construction and use in preference to the tamped one.

Most commercial molds make a post which tapers from the base to the top, but the most economical mold is one which casts a post as large at the ground line as at the base, tapering from the ground line to the top. For a description of this form of mold, see Fig. 4.

The best form of post is one which is equally strong from all directions. The square, or round post, fulfills this requirement. The triangular post does not meet the requirements because it cannot be economically constructed so as to be equally strong from all directions.

To be economical, the amount of reinforcement should be in proportion to the size of the post and strength of the mixture. See tables.

The material used for reinforcement should be strong, light and rough enough to permit the mixture to get a firm grip upon it. It should be very rigid, with little or no tendency to spring or stretch.

The smooth reinforcement tends to slip even if hooked at the ends.

Two or more wires twisted together make as satisfactory a reinforcement as can be obtained.

Crimped wire tends to strengthen and thereby breaks pieces out of the post at the point of greatest stress.

The reinforcement should be placed in each corner of the post at a depth of from ⅜ to ¾ of an inch from the surface.

There are several commercial wire fasteners now found on the market, the most of which are either cumbersome or expensive. For a simple and satisfactory fastener, see cut of fasteners. (Fig. 5, A.)

The posts should be cured in the shade for at least 60 days, the first 30 days of which they should be sprinkled daily.

Bulletin 149 June, 1909

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

PART I.
CARRYING RANGE STEERS THROUGH THE WINTER.

PART II.
SUGAR BEETS FOR FATTENING STEERS.

BY

W. L. CARLYLE

AND

G. E. MORTON.

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1909

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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PART I

CARRYING RANGE STEERS THROUGH THE WINTER

W. L. CARLYLE and G. E. MORTON

INTRODUCTION

Cattlemen are at variance in their opinions as to whether range steers should be winter fed as calves and as yearlings, when they are to be carried over for fattening as two-year-olds. And an equal divergence of opinion exists as to whether it is wise to carry steers to that age before finishing. The experiment detailed in PART I of this bulletin was outlined by Prof. W. L. Carlyle in 1905 and carried out under his direction until its completion in 1908. Professor J. A. McLean and the writer, who succeeded him, carried out the winter feeding work with the steers. The writer is the only one of these three at hand at the publication of the bulletin, and as he did not see the first two years of the experiments, he finds it difficult to make as thorough a writ-up as he would like. The data presented is sufficient, however, to indicate the answers to one or two questions concerning winter feeding of store steers.

PLAN OF THE EXPERIMENT

In the fall of 1905, 20 head of representative steer calves were secured from the herds of W. H. Gerdts, Cope, Colo.; E. M. Ammons, Littleton, Colo., and I. B. Griffith, New Castle, Colo. Three calves were Hereford grades, and were brought to the College for winter feeding. A like number of representative steers of the same crop were brought to the College from these herds in the fall of 1906, and again a like number in the fall of 1907, with the exception that the five head from Mr. Griffith's herd were not secured in 1907, because of shipping difficulties.

Each summer the steers, which had been winter fed at the College, were turned out upon enclosed range, owned by the College and located on the foot hills west of Fort Collins.

In this way some of the steers were winter fed as calves, as yearlings and as two-year-olds; some were fed as yearlings and as two-year-olds; and some fed only as two-year-olds.

Again, some of the steers fed as calves were finished off as yearlings, while others were not marketed until they were twos.

The following table shows the weights and gains made by the steers each season:

AVERAGE WEIGHTS AND GAINS OF ALL STEERS FOR EACH SEASON

	Average Weight Fall of 1905	Average Weight Spring of 1906	Average Gain Winter 1905-06	Average Weight Fall of 1906	Average Gain Summer 1906	Average Weight Spring of 1907	Average Gain Winter 1906-07	Average Weight Fall of 1907	Average Gain Summer 1907	Average Weight Spring 1908	Average Gain Winter 1907-08
Steers Fed as Calves, 20 Head.....	404	663	259	804	141	1094	290	1145	x62	1368	223
Steers Fed as Yearlings, 20 head.....				644		984	320	1046	*95	1407	361
Steers Fed as Two-Year-Olds, 15 Head.....							-	911		1146	235

x The average weight of six head which were kept over, their average weight in the spring of 1907 being 1083 pounds. The other 14 head were sold in the spring of 1907, average weight 1099 pounds.

* The average weight of the 14 head which were kept over, their average weight in the spring of 1907 being 951 pounds. The other six head were sold in the spring of 1907.

In discussing the table, we will first take up this question:

If you expect to feed steers out at two years of age, does it pay to winter feed them either as calves or as yearlings?

The steers fed during the third winter only—the winter during which they were fitted for market—gained 235 pounds per head and weighed 1146 pounds, while those fed the second and third winters, gained 361 pounds the third winter and weighed 1407 pounds. The latter not only weighed 261 pounds per head more because of their previous feeding, but were in better shape to put on good gains the winter they were finished out, putting on 126 pounds per head more weight than the steers fed the third winter only. Another point in their favor was that the extra weight was in fat rather than in frame, as they were valued at the close of the third winter, when ready for market, at $6.20 per cwt, while the steers fed the third winter only, were valued at $5.75 per cwt. These valuations were made by Mr. Henry Gebhardt, of Denver, without knowledge of what lots the steers were from.

Mr. Gebhardt, at the same time, placed a valuation of $6.10 upon the steers brought in to the College in the fall of 1905 and fed all three winters. These steers made a gain of only 223 pounds per head the third winter,—less than either of the other lots; and they showed an average weight of 1368 pounds per head, or 39 pounds per head less than the steers that were not winter fed as calves, and 222 pounds per head more than the steers that were not winter fed either as calves or yearlings. These results plainly show that winter feeding the calves was not profitable when the steers were to be held over to be finished off as two-year-olds, for the lot that were not winter fed as calves, but were fed the two succeeding winters, not only made the largest gain during the last winter, but showed the heaviest average weight, and were in best market condition.

We can state then, so far as the gains made by these steers are concerned, that when the aim in view was to finish the steers as two-year-olds, the feed put into them as calves was wasted, but feeding them the winter they were yearlings put them in shape to make better gains the next winter and made better market steers of them. This result does not coincide with the view of those cattlemen, who believe that if only one winter's feed is to be given previous to the winter of finishing, that feed should be given the calves in order to retain upon them their baby flesh. But a study of the weights and gains of the steers brought in as calves will bring out the reason, I believe, for the poor showing made by these steers the third winter.

WEIGHTS AND GAINS OF STEERS FED THREE WINTERS AND THOSE FED TWO WINTERS

Weight	Steers Fed Each Winter		Steers Fed Two Winters	
	Weight	Gain	Weight	Gain
Fall of 1905 (Calves)	404			
Spring of 1906	663	259		
Fall of 1906	804	141	664	
Spring of 1907	1094	290	984	320
Fall of 1907	1145	62	1046	95
Spring of 1908	1368	223	1407	361

You will note the heavy gain put on by the calves during the first winter's feeding—almost as much as they put on the next winter as yearlings. As a consequence, they weighed, the fall that they were yearlings, 140 pounds per head more than the steers of the same crop brought in from the range as yearlings. The next spring they were only 110 pounds heavier, the next fall 99 pounds heavier, and the spring they were marketed, 39 pounds lighter than the steers brought from the range as yearlings. This gradual decrease in the margin between the two sets of steers indicates that the winter feeding as calves hastened the steers to maturity and consequently lessened their power for gain each successive season at a rapid rate.

Another way to look at the question is to compare the gains made each year by the same lot of steers. The lot fed as calves made a gain of 400 pounds per head the first winter and succeeding summer; the next year they made 352 pounds gain per head—already starting down hill you notice—and the last winter they made a gain of only 223 pounds per head, or 36 pounds per head less than they made the winter they were calves.

Considering the year when they were one year old, they made a gain of 431 pounds as against a gain of 285 pounds when two-year-olds. And the steers that were not fed until they were yearlings made a gain of 456 pounds the year that they were twos.

WEIGHTS AND GAINS OF STEERS OF THE DIFFERENT BRANDS

All Steers are of the Same Age, Calved 1905. See Note

	Fall 1905	Year 1905-06	Winter 1906-07 to April-2nd	Summer 1907		Winter 1907-08
				June 7thx	Oct. 26th*	
VI—1905				(3)		
Total (10)	3527	7646	9930	3125	3320	4230
Average	353	765	993	1042	1107	1410
Average Gain		412	228		65	303
VI—1906				(6)		
Total (10)		6857	9595	5790	6360	8390
Average			960	965	1060	1398
Average Gain		686	274		95	338
VI—1907						
Total (10)					9265	11360
Average					927	1136
Average Gain						209
U—1905				(1)		
Total (5)	1870	3999	5155	1210	1240	1240
Average	374	800	1031			
Average Gain		446	231		30	0
U—1906				(5)		
Total (5)		2968	4218	4625	5090	7165
Average		594	844	925	1018	1433
Average Gain			250		93	415
U—1907						
Total (5)					4400	5830
Average					880	1166
Average Gain						286
1—L 1905				(2)		
Total (5)	2690	4398	5427	2165	2310	2740
Average	538	880	1085	1083	1155	1370
Average Gain		342	205		72	215
1—L 1906				(3)		
Total (5)		3464	4455	2905	3200	4150
Average		693	891	968	1067	1383
Average Gain			198		99	316

NOTE—For convenience the steers are designated by the year during which they were brought from the range. For example U—1906 means the U—steers brought to the College from the range in the fall of 1906, the steers then being yearlings.

*June 7th was the date upon which the steers kept over were put out to pasture.

xThe figures in brackets in this column are the number of head of steers not sold and put out on pasture June 7th.

Thus any way one wishes to look at the problem, the feeding of calves does not appear profitable if they are to be held over for finishing as two-year-olds. The amount of feed used is not considered in the discussion above, because the interpretation of results could in no way be affected by the cost of the feed, save for the general statement that the greater the cost of feed for calves, the greater would be the loss to the feeder.

FEEDING TWO WINTERS OR ONE

In considering winter-feeding for two winters compared with feeding the third winter only, we must note first of all that the steers fed as yearlings weighed 261 pounds per head more at marketing than the steers fed the last winter only, and were worth 45 cents per cwt. more than the latter. They were both heavier and fatter. Whether this extra weight and fatness paid for the feed put into them as yearlings is problematic. The feed for the steers, brought to the College in different seasons was not kept separate, so that the feed per head as shown in the following table is an average for all the steers:

AVERAGE FEED AND GAIN PER HEAD
2nd and 3rd Winters

Season Winter	Number Head	Average Weight at Close Winter	Average Gain During Winter	Feed Per Head in Pounds			Cost of Feed Per Head
				Corn	Alfalfa Hay	Sugar Beets	
1906-07...	20 (held over)	991		992	2644	1306	$19.89
1906-07...	20 (sold)	1087		1203	2536	2270	24 04
1906-07...	40 (all)	1039	307	1138	2660	1921	22.83
1907-08...	35	1289	284	1252	2835	1998	24.60

NOTE—Price of corn, $1.00 per hundred; price of alfalfa, $5.00 per ton; price of beets, $5.00 per ton.

AVERAGE FEED AND GAIN PER HEAD 2ND AND 3RD WINTERS.

The steers denoted in the second column of this table as "held over," comprised six head of the steers fed as calves, and 14 head of those brought in as yearlings. The average feed per head for these during the second winter was 992 pounds of corn, 1306 pounds of sugar beets, and 2644 pounds of hay, or in round numbers ½ ton corn, 2¼ tons of hay, and 2/3 of a ton of sugar beets. At the prices listed, this feed cost about $20.00 per head ($19.89). With alfalfa hay at $10.00 per ton, the cost of feed would be raised to about $26.00 per head.

Now for returns. Assuming that the feed during the third winter, for the two lots under discussion, was approximately equal, as assumption not out of the way, the extra income from the steers fed two winters may be credited against the first winter's feed. Referring again to Table A, we find the steers fed the second and third winters weighed 1407 pounds per head at the close. This weight at an advance of 45 cents per cwt. over the other steers, means $6.33 credit. Then 261 pounds extra weight at $6.20 gives $16.18, or a total of $22.51 to credit against the feed. And yet another item is to be taken into consideration, the College range is not good range late in the summer, which accounts for the low gains made each summer. Any range man would expect to secure larger gains than are shown by the spring and fall weights of these steers. So that with this evidence before us, I believe the winter

feeding as yearlings was a paying proposition. It is by no means proven, but the indications are strongly in that direction. With so many problems involved in this one experiment, it is difficult to make a clean cut conclusion on each issue. While we have convincing proof that the winter feeding of calves, destined to be fed each winter until sold as two-year-olds, was a losing proposition, all we can say concerning the question at issue is this: The winter feeding of yearlings destined to be fattened and sold as two-year-olds, resulted in heavier, fatter and more marketable steers; and besides producing good gains during the winter in which the feeding was done, produced residual feeding effects shown by very heavy gains the winter they were finished. And so far as we can tell from the results at hand, such feeding will ordinarily produce a profit if feeding stuffs are not too high priced.

FATTEN YEARLINGS OR TWO-YEAR-OLDS?

But another question arises: *Does it pay better to winter feed as calves and finish as yearlings, or winter feed as yearlings and finish as twos?*

This question involves many more points than those taken up in this feeding experiment, so that it cannot be answered fully here. But we can furnish some data of use to the cattleman in figuring the problem for himself. The problem as it lies before the cattleman is this: If he fattens his steers as yearlings, he must charge all loss of cows and calves and depreciation of value in the young cows against this one year's running of the steers; while if he carries the steers two years he may distribute this charge over two years. On the other hand if he feeds as yearlings he gets cheaper gains on his steers, as one will on all young animals, and he releases his capital so that it is turned over every year instead of every other year. He does not need to make so large a profit on the yearlings, because he will make that profit twice as often.

The light which this experiment throws on that problem, consists in a definite knowledge of the gains made by steers during the different seasons as is shown in Table A.

The steers winter fed as calves made a gain during that winter and the following summer of 400 pounds; while the steers not fed until the winter they were yearlings made a gain during that winter and the following summer of 415 pounds. With practically equal gains, the calves undoubtedly put on their gain much more cheaply than the yearlings. By referring to PART II of this Bulletin it will be seen that yearlings put on their gain at about two-thirds the cost of the gain put on by two-year-olds. The second winter's feeding shows two-year-old steers weighing 1046 pounds per head in the fall, making a gain of 361 pounds per head during the winter; while yearling steers weighing 804 pounds per head made a gain of 290 pounds. The two-year-olds gained 34.6 per cent. of their live weight, while the yearlings gained 37.3 per cent. of their live weight. This again is in favor of the younger steers.

Upper picture—Steers when calves.
Centre picture—Steers coming two-year-olds.
Lower picture—Open shed in which steers slept and were fed grain. Hay racks in foreground.

During the winter of 1905-06 the calves were fed upon beet tops until the 15th of February, running in the fields with stock cattle. When taken from the beet fields ten head were fed a ration of four pounds daily of ground corn with alfalfa hay; while the other ten head were fed a ration of twenty pounds per head of sugar beets. Both lots made approximately the same gains, the only difference being that the lot fed beets ate somewhat less hay. For the purposes of this discussion, it is sufficient to say that the amount of feed consumed by the younger animal is less than that consumed by the older. And from this standpoint of feeding alone, it seems more economical to winter feed as calves and finish as yearlings than to winter feed as yearlings and finish as two-year-olds.

FINISHING YEARLINGS

If you intend to finish steers as yearlings, is it profitable to feed them hay and grain the winter that they are calves?

The steers winter fed as calves gained 30 pounds per head less during the winter they were yearlings, than the steers gained that were not winter fed as calves; but they averaged 110 pounds per head more in weight than the latter and sold for 25 cents per cwt. more. This offers no satisfactory conclusion without a knowledge of the cost of feed. However, the calves fed during their first winter gained 259 pounds per head that winter, and yet were only 140 pounds heavier the next fall than those not winter fed. This indicates a poor summer gain, which their gain of 141 pounds per head undoubtedly was. The steers in this experiment lost a great deal of flesh when first turned on the range and did not thrive at any time during the summer as range cattle wintered on hay would have done. The only conclusion that one can come to with the insufficient data at hand, is that whether or not there be profit in winter feeding of calves destined to be sold as yearlings, depends upon the condition of the range upon which they were run. It is more a question of grass and storms than one that can be settled definitely for all conditions.

MARKET VALUE OF THE STEERS

The last spring of the experiment when all of the steers were coming three-year-old, Mr. Henry Gebhardt, of Denver, put a market valuation on the three lots of steers, without knowledge as to how each lot had been handled. He valued the steers that had been fed every winter at $6.10 per cwt.; those fed two winters at $6.20 per cwt., and those fed one winter at $5.75 per cwt. These prices indicate the comparative condition of flesh of the various lots, and the valuation given corresponds to the final weights of the three lots.

These market prices mean that the steers which were not fed as calves, but were fed the winter that they were yearlings, then put back on the range, and finished out as two-year-olds, not only made the most rapid gains and were heaviest when put upon the market, but were fattest, having put on a large proportion of their gains in flesh and fat.

FAT, BONE AND LEAN MEAT IN A RIB CUT

Rib roasts, comprising the 8th and 9th ribs and measuring 5 inches in width, were taken from the carcasses of the two steers.

One steer, A, which had been fed both the winter he was a yearling and the succeeding winter, was killed in April, weighing 1440 pounds. The other steer, B, which was fed only as a two-year-old, was held until August after steer A had been killed, when he reached the 1400 pound weight.

The rib cuts taken were dissected with the following results:

	Lean Meat	Fat	Bone
Steer A.....	8 lbs. 13 oz.	8 lbs. 12 oz.	2 lbs. 4 oz.
Steer B.....	9 lbs. 2 oz.	7 lbs. 5 oz.	3 lbs.

These figures show little difference between the steer which had been fed two winters, and the one fed only one winter. What difference there is shows more bone and lean meat in the animal fattened rapidly at a later stage of life. There was practically no difference in the appearance of the rib cuts from the two steers.

PART II.

SUGAR BEETS FOR FATTENING STEERS.

The steers used in the experiment, described in Part I, were fed during each winter with a view to finding the value of sugar beets in replacing part of the corn used with the customary corn and alfalfa ration in Colorado. European and Canadian feeders regard roots highly as an aid in finishing cattle, but in America it has been difficult to popularize their use. Many inquiries have come to this Station, however, as to the value of sugar beets for stock feed, and in conversation with feeders, I find that many are firmly convinced that sugar beets possess a feeding value of from $5.00 to $10.00 per ton. Results of experiments conducted in other states indicate a much lower value than this for feeding, and the following experiments were conducted with a view of ascertaining the true value of sugar beets for feeding under Colorado conditions. The results obtained throw considerable light upon this question.

EXPERIMENT I

In this trial of 16 weeks, Lot 1 was fed six pounds of corn and 30 pounds of sugar beets per head each day, while Lot 2 was fed 12 pounds of corn. This meant replacing half the corn with sugar beets in the proportion of 5 pounds of sugar beets to one pound of corn. The steers were yearlings.

FEED, GAIN, AND COST OF GAIN

Lot	No. in Lot	Total Gain in Weight	Total Feed Pounds			Average Gain Per Head	Pounds Feed Required For 100 lbs. Gain			Cost of Feed 100 lbs. Gain
			Corn	Sugar Beets	Alfalfa Hay		Corn	Sugar Beets	Alfalfa Hay	
1....	*	4714	9245	52234	30194	239	196	1108	641	$6.33
2....	**	4256	18851		30640	216	443		720	6.23

* At first 18 head, after 3rd week, 20 head.
** At first 17 head, after 3rd week, 20 head
Note—Corn at $1.00 per cwt., Beets at $5.00 per ton, Alfalfa Hay at $5.00 per ton.

The steers fed the sugar beets made somewhat better gains than the others, averaging 23 pounds heavier at the close. By inspection of the columns showing feed required for 100 pounds gain, we find that 1108 pounds of sugar beets replaced 247 pounds of corn and 79 pounds of alfalfa hay; or 4.5 pounds of sugar beets replaced 1 pound of corn and .32 pounds of hay in the production of 100 pounds gain in live weight.

Figuring corn at 1 cent per pound, sugar beets at $5.00 per ton, and hay at $5.00 per ton, the sugar beet ration cost $6.33 for every hundred pounds gain produced, while the corn ration cost $6.23. These results indicate that if corn costs more, or sugar beets less than these prices, it will pay to substitute sugar beets for half of the corn ration.

Interior of Steer Shed, Showing Grain Trough

Range on Which the Steers Were Run in Summer

SECOND TRIAL 1907-1908

This trial lasted 22 weeks. The steers were two-year-olds. Lot 1 was fed 12 pounds of corn per head each day, while Lot 2 was fed 6 pounds of corn and 30 pounds of sugar beets.

FEED, GAIN, AND COST OF GAIN

Lot	No. in Lot	Total Gain in Weight	Total Feed Lbs.			Average Gain Per Head	Pounds Feed Required for 100 Pounds of Gain			Cost of Feed For 100 lbs. Gain
			Corn	Sugar Beets	Alfalfa Hay		Corn	Sugar Beets	Alfalfa Hay	
1....	17	4425	28454		52653	260	643		1190	$9.41
2....	17	4655	15375	69931	46560	259	330	1502	1000	9.55

Note—Corn at $1.00 per cwt., Beets at $5.00 per ton, Alfalfa Hay at $5.00 per ton.

The two lots of steers made equal gains. 1502 pounds of sugar beets replaced 313 pounds of corn and 190 pounds of hay in the production of 100 pounds gain, or 4¾ pounds of sugar beets replaced one pound of corn and ¼ pound of hay. Figuring prices of feeds the same as in the previous trial, the sugar beet ration cost $9.55 for every hundred pounds of gain produced, while the corn ration cost $9.41. The greater cost in comparison with the former trial is undoubtedly due to the greater age of the steers.

This trial is so closely in accord with the previous trial with regard to the amount of beets necessary to replace half the corn ration, that we may state with reasonable certainty, that sugar beets when fed with a half ration of corn, have a feeding value of about one-fifth that of corn; it will take from 4½ to 5 pounds of sugar beets to give the results produced by one pound of corn.

The steers used in the second experiment were priced by Mr. Henry Gebhardt, of Denver, without a knowledge as to the manner in which they had been fed. He valued the steers fed on sugar beets and corn at 10 cents per hundred weight less than the steers fed corn, so that the finish of the steers in one lot was not much different from that in the other.

Bulletin 150 June, 1911

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

On the Measurement and Division of Water

BY

L. G. CARPENTER

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1910

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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ON THE MEASUREMENT AND DIVISION OF WATER*

By L. G. CARPENTER†

Questions concerning the measurement and division of water probably give rise to more trouble than all other questions combined in an irrigated country. While frequently the amount of water in dispute is small it may be and often is, a serious matter. It certainly is a source of irritation, causing constant friction between the management of a canal and the consumers, and between neighbors. It is more troublesome because of the well-known fact that a stream of water always looks larger in the neighbor's ditch than in one's own. It is irritating because neither disputant can convince his opponent or even satisfy himself, and hence for the lack of knowledge of how to determine the fact, assertion takes the place of demonstration. A more widely distributed knowledge of methods will remove much of these troubles, as it already has.

When the water supply is scanty, error may be a very serious matter, for the crops of the user may depend on a small quantity of water, and gives cause for strenuous dispute. This has been the case from time immemorial and the serious disputes thus arising are embalmed in a curious manner in one of our words in common use. In old Roman times, an artificial water channel, therefore a ditch, was a "rivus," and the users from such a water course were "rivals;" and the conflict in interest indicated in this word, comes from the typical case of users from the same irrigation ditch. This same difference in interests persists today as it did at the time when their disputes became notoriously difficult of settlement.

The problem of a just distribution of water is therefore one of the most important, as well as one of the most difficult problems of canal management. Frequently, in fact generally, the measurement becomes one of approximation. The practical need is to obtain a method that is sufficiently exact for the given conditions and also—which is sometimes of greater practical importance—to secure one which will inspire confidence.

The measurement of water and the division of water may be two distinct though closely related problems, so that a method which is intended for measurement serves also for division. It should be clearly understood that no one method will apply to all situations. Methods suitable to a canal of heavy fall and with a heavy fall in the laterals, cannot be available where the fall is

*The first edition of this bulletin was issued in October, 1890, a reprint in July, 1891. The third edition, with additional tables and considerable revision, was issued as Bulletin 27 in 1894. The trapezoidal weir first described in the early editions of this bulletin has been very widely adopted on the American continent.

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small or where the land to be supplied is nearly on the same level as the canal. Methods to be used where the water is clear may be impossible in streams carrying large quantities of silt. Likewise, the methods must often be adapted to satisfy conditions of local contracts or to accord with local customs. No system will work without intelligent supervision. A poor method may work out satisfactorily, provided the man in charge has experience and good judgment. Sometimes even a good system will not be free from trouble unless administered by capable men. Hence one of the necessary requirements in canal management is to educate the superintendents and riders so that they have sufficient understanding of the principles of measurement to apply them to the exceptional cases. The men also need the confidence of the users. Users are suspicious, and hence it is as important, perhaps more important, for the successful management of a canal, to have a system which appears to be fair as to have one which is fair, but is not apparent. Hence an important feature is a measurement which shall be simple and which may be understood by the user. It thus saves unpleasant disputes and arguments, strengthens the faith in the ditch rider, and relieves him from clamor of those who think that the way to get their share is to claim more than they are entitled to.

The bulletin will describe some methods of the division of water adapted to the use of small ditches and laterals, and also methods of measurement which may be used in large ditches. It especially explains the use of the weir, the conditions under which it should be placed and the extent to which it can be relied upon, and also tables for its use.

In the previous editions of this bulletin, descriptions were made of the rectangular and of the trapezoidal weir with sides inclined at one-fourth to one. The description of this weir in 1890 was the first description of this form of weir in English. Because it had been proposed by the engineer of an Italian canal, I called it after him, the Cippoletti weir. From the description and recommendation given in Bulletins 13 and 22, its use has widely spread over the irrigated sections. It has been adopted by various experiment stations, by the state engineers of all of the western states, and by the United States Department of Agriculture, but in most cases without credit to the author or to the station. The recommendation given in Bulletin 13, (1890), and Bulletin 27, (1894) has sometimes been taken too broadly, but as a whole the endorsement there given has been justified. The statement there made that I considered it to be the most advantageous of any module for irrigation purposes, should not be taken to mean that it is the most accurate. The only advantage over the

rectangular weir is that its discharge is proportional to the length. This is a great convenience in the practical operation of a canal, with many suspicious consumers, who do not understand the facts of hydraulics. It avoids the attempts to explain the effect of end contractions called for in the rectangular weir, and the difficulty found by the ditch riders to do this helped to increase suspicion rather than inspire confidence.

It should also be clearly understood that there is no one form of opening which is intrinsically better than another. There may be many other forms with accuracy as great or equal to the rectangular weir. At present, however, the rectangular weir has been subjected to experimental tests under so many conditions that its peculiarities are well known and this is true only to a limited extent of other forms. The flow of water over weirs has been most rebellious to theory. But as their discharge has been measured under different conditions, and the requirements for placing are so simple they can be established with confidence in the accuracy of the results. Tests have been made in such number that more confidence can be felt in it than in any other form of opening, and hence, while the knowledge of other forms may be increased in the future and thus other forms of opening come into use, some form of weir is the one best worthy of confidence at the present time. In this bulletin the triangular notch is also shown more at length. It is capable of use for small laterals and has some advantages over the rectangular weir for that purpose. The conditions for placing it are the same as for the weir, and tables are newly calculated for the discharge. The advantage of the triangular notch over the weir is that only one measurement is necessary—that of the depth—while in the case of the weir, both the length and the depth need to be measured. The triangular notch is not adapted to large quantities of water, but inasmuch as one with a depth of one foot will discharge over two cubic feet of water per second, it gives as much as most individual laterals call for, and therefore can be used on ditches as distributing weirs, where the rectangular or trapezoidal weir is used on the larger lateral or main canal.

The importance of measurement, both to the community and to the public wealth, scarcely needs mentioning. Where water has been plentiful in the streams and ditches, as was the case in the beginning, the necessity for close measurement was not felt, for there has been water enough for all but with greater demand for water, with the pressing necessity to make every drop available, and with the increase in the value of water, we are led to consider more efficient means of measurement and distribution. This is the history of the development of every irrigated community from

earliest times and will continue to be so. The need is increasingly exacting, for the pressure for water progressively increases.

The prevention of waste is a matter of public importance. The land suitable for irrigation so much exceeds the water supply, not only in Colorado but throughout the West, that the agricultural development depends on the use of the supply to its fullest capacity. Though the building of storage reservoirs, the stopping of waste, improved methods of irrigation which were all recommended in Bulletin 13, (1890), have been carried out to a great extent and the agricultural products, if not the agricultural area, has greatly increased, and much improvement in measurement has come, the pressure remains about the same. A larger saving will be effected in the future as it is found that less quantities of water are needed; subdivision into smaller and smaller streams becomes necessary and measurement will become more exact, and it will be justifiable to expend larger sums for exact devices.

Aside from the accuracy, a good system of measurement saves a large amount of water. A careful account is known to be the basis of sound finance. An accounting, in itself, produces economy for it causes an arrest of thought, and directs attention to the matters under consideration, and reveals the source of waste. It is also true in water administration. The very fact that water is measured checks extravagance. If it be not measured the idea is easily fostered that it is not valuable enough. The mere fact that measurement is made and an account kept, makes each user more careful. In ditches where no attempt has been made to control the use by individuals, it is surprising to notice the saving caused by keeping an account and thus showing how much each has used and to compare one with another. In cities it is well known that the mere installation of water meters and keeping account of the water used by each individual, often reduces the consumption to one-third what it was before, and yet no one has suffered. When water is plentiful, a system, or lack of system, works without trouble. The practice then is to give water enough to stop complaint. When the water becomes scarce, then inexactness in measurement means that someone gets more than his share. This means that some one else gets less; and the result may be serious upon the crops.

In all parts of the State where the pressure for water is felt, there has been a great increase in the value of land, and this is almost entirely from the increase in the value of water. Reservoirs have been built at an expense of millions of dollars to take advantage of streams of water that a few years since were considered to be insignificant. This increase in the value of water has only begun, and therefore the conditions which justify pains and

expense to obtain accurate measurements, will increase. Companies will go to much greater expense for this particular purpose than they now consider justifiable. It is true that the present practice is generally behind what could reasonably be expected from present conditions.

Even now in the exchange between reservoirs in northern Colorado, the companies have found it justifiable to employ a skilled person for that particular work, at considerable expense. The statement made in the first edition may be repeated:

> "There will never be an easier time for arranging satisfactory measurements than now; for the demand will not be less, and with time and the increase in the value of water, there will be many who will feel that they have rights vested in certain methods of measurements which may be intrinsically unjust."

For many years I have had occasion to pass over the ditches in Colorado in detail. This was generally in company with the ditch rider or superintendent. Thousands of miles were thus traversed. In so doing, I made the methods of distribution the subject of special observation and inquiry. In general, it was found that the methods were exceedingly unreliable. There has been a great improvement both in the methods and in the qualifications of the ditch riders, yet the same statement may still be made. In many canals the measurement depends on the eye and judgment of the ditch rider. In others, the measurement is nominal and really worse than none, because it gives a false idea of accuracy, and, so long as it prevails, it stands in the way of the introduction of a better system.

This bulletin was originally prepared because of the need then observed, of greater knowledge of methods of measuremnt, and was based upon the study of the devices as they existed, and of the methods used in other states and other countries. There is a chance for great improvement. I have found discrepancies amounting to as much as 400%. No method should be considered meeting the conditions of today unless it is correct within 5% or 10%. The practice is not often so accurate as this, and yet it is not difficult to bring it within 5%. Increase in accuracy means more pains and therefore more expense, but with the value of water, more expensive methods are justifiable and precautions can be taken which would have been out of consideration in times past.

On this subject, as well as on others in the line of irrigation, the experience of Italy is suggestive, even if it cannot always be taken as an example. Their physical conditions have much that is similar to ours. Our development has followed hers, though we have condensed her growth of six centuries into fifty years. The physical laws governing the flow of water, the principles involved

in the distribution and measurement, are the same. We are finding certain laws and regulations to be necessary which they found to be necessary centuries ago. They have outgrown their first crude methods. One of their most widely used modules was based upon an erroneous idea. It was early introduced into Colorado and used on some of the earlier ditches.

The need for measurement dates back to the beginning of irrigation. The methods were necessarily adopted without much hydraulic knowledge. That they were fairly satisfactory, reflects credit upon those who had to make them. This is especially true in regard to the well-known Milanese module produced by Soldati, and adopted by the magistrates of Milan. But we find fairly workable methods, crude to be sure, but adapted to the conditions, among the ancient Romans, among the Moors, and among almost all users of all nations who have tried to make a fair division of a fluctuating quantity. The modern Italian canals, like the Cavour Canal, the Canale Casale, Canale Villoresi, have adopted methods of measurement depending upon the weir. While the old measuring box or module is still used on the ancient canals of Lombardy, it has had to be modified to meet modern conditions. Other provinces or coommunities have generally other methods. In some cases users have acquired rights under a particular manner of measurement. They are afraid of any change for it may affect their rights and thus arouses intense opposition. Soldati met with so many difficulties in the attempts to reform the system of measurement and with such violent abuse that he met the fate of the reformer who attempts to change the settled customs of a people. This may be, and often is, a kind of conservatism but becomes a violent opposition among those who think they are affected. The same kind of conservatism is shown in Colorado. The same varied customs which gave rise to the abuses in Italy which Soldati tried to check are becoming fixed. There are numerous canals in which there are different classes of users. Their rights are different. Water is measured to them in different manners, or at least on a different basis. This introduces problems of measurement much more complicated, but not different in kind, and sometimes makes a difference in the method required. Thus, as an illustration, one canal which may be taken as fairly typical indicates the character of the questions of measurement which arise. That canal includes the following classes of rights:

1. What may be termed as preferred rights. A number of users entitled to unlimited water without measurement and without assessment. These are due to special contracts whose origin generally lie in the fact that the canal has been the successor of an earlier ditch and the users in the earlier ditch have relinquished their ownership for this consideration.

2. The ordinary stockholders, each entitled to a proportionate part of the water remaining after the first class has been supplied. Sometimes the amount of water is limited to a prescribed amount. In this case serving as an illustration 4 shares is limited to 1.44 second feet, intended for 80 acres of land.

3. A class of residuary rights—persons who are not entitled to any water until classes 1 and 2 have received their amount; they are entitled to whatever is in excess. These are surplus rights without vote in the management.

4. Persons using the canal as a common carrier. A case arises, for example where the water of a reservoir is run through the canal to its stockholders, who may or may not be stockholders in the canal. There may be several different and independent sources of water each requiring independent treatment. The charge for carriage may be for money or for a fraction of the water carried.

The classes of the first three kinds have been common in Italian practice for generations. Some of these privileges existed in the time of the Caesars and are mentioned in Frontinus account of that period. They have developed with us and will in any irrigated country, because the situation naturally gives rise to the conditions calling for them.

Hence it may be realized that the problem of distribution, which is necessarily a difficult one, becomes additionally complicated. It may be realized that the solution is not exact, especially as additional complications are introduced from the ever-varying losses from evaporation and from seepage; from the fluctuating needs of different users, which vary from hour to hour; from the fluctuating supply entering the canal, due to the effect of the varying draft of other ditches and from the diurnal fluctuation in the river itself; and to the complicating effect of the time which is required for water to pass down the canal, which in some of the larger ones may be several days.

In the measurement of water from ditches there are two distinct classes of measuring boxes—one is the dividing box and the other the measuring box or module. The object of the former is to furnish a definite portion of the water flowing in a ditch. The need of this form of box is more common in small ditches owned by two or three neighbors, or in minor ditches with a limited number of stockholders. The intention is to give one person, for example, one-fourth, or some other fraction, of all the water that enters the ditch, this fraction being in proportion to his interest. It is thus best adapted to short ditches or cases where the number of people are few and where the expense of a ditch rider or patrolman is to be avoided.

The other class of box is the measuring box, whose object, in general, is to give a certain definite quantity of water, as one cubic foot per second. Sometimes the attempt is to deliver a constant quantity of water. This purpose, however, is not usually necessary or desirable. Under conditions in the western part of

the United States, the quantity taken by the ditch, and therefore by the laterals, is constantly varying. In most cases a user is entitled to a certain fraction (depending upon his number of shares of the capital stock) of the whole amount of water. Most contracts reduce to such a statement in the last analysis. If there be 600 shares outstanding, then omitting the more complicated cases which, however, are the common ones, each share is entitled to 1-600 of the available supply. Hence in nearly every case the problem becomes essentially one of equal division, complicated by various other conditions. There are few cases in which the consumer can demand a constant flow of a definite quantity. This requirement is not necessary and is rarely desirable. In most canals, where there are a large number of users, the simplest way of giving each person his share is to measure out a definite quantity. The manager or ditch rider determines how much water is available, after allowing for the loss by seepage and evaporation which experience has shown for that particular ditch. Perhaps he may be limited by the amount in the stream and this may be fluctuating. Then knowing from the reports of the ditch riders how many shares will call for water, he divides the available amount of water by the number of shares so calling, and thus determines how much is available for each share. The object is, then, to measure to each his proportional amount. Like the depositors in a bank, it is rarely that all users call for water at the same time. If the supply of water for the canal is constant and the demand is constant, then the flow to which each share is entitled is constant. Practically, however, this is never the case; hence, it is more important that the boxes be capable of exact measurement and of adjustment than it is that they give a constant flow. The fluctuating conditions are met by setting the boxes or adjusting the gates once or twice per day or oftener in strenuous times. At best this is an approximation. I am inclined to think that with the development of a practicable register of low cost, less attention will be given to the daily adjustment. This is already done in the case of reservoir water.

The class of measuring boxes adapted for measurement has been called by the Italians, "Modulo." It is more convenient in its French form, "Module," and this name therefore, is used to designate those boxes whose object is to measure the quantity of water delivered, or to give a constant flow. The word, "Divisor" will be restricted to the class of boxes, previously referred to, whose only object is to divide water.

There will always be cases where the Divisors are the most convenient, especially in the small ditches. In all other cases modules of one kind or another will be found to be the better. The problem is to determine the one best adapted to the special

conditions, which is most reliable, most accurate, and which has the fewest objections.

In the case of divisors it is evident that there is no unit of measure, and that none is needed, for the object is to give the user some fractional part of the water flowing in the ditch, whether there be much or little.

In the module, on the contrary, some unit of quantity is needed, and this, with us, is a cubic foot per second, a unit which has now become established through all the western states. The term "inch" has been widely used in the western states and gives a notion of unit, but does not have any of the essential characteristics. The essential character of any unit is that it has a definite value and is one which can be reproduced. Also, in case it is multiplied, ten units should be ten times one unit. There is the "water inch," or "miner's inch," the "statutory inch," and the "customary inch" with infinite variations, used in such a multitude of meanings that it is an almost hopeless task to express an exact idea of quantity. The term has been convenient to use, notwithstanding its inaccuracy. It was used in Italy for thousands of years in essentially the same meaning.

In the case of flowing water it is manifest that the amount passing through a given channel depends upon the speed of the water, as well as upon the section of the channel. In the inch system of measurement, account is taken of the cross section and not of the speed of the water. Some attempt is often made to regulate the speed by providing that the pressure of water over the opening shall be always the same. In such cases the area of the opening in square inches is counted as inches of water. As there are other conditions affecting the velocity of the water, there is still room for very large differences in velocity, and consequently the same unit may mean very different quantities of water.

An inch of this kind is recognized in the Statutes of Colorado, and defined in the laws of 1868 as follows:

> **"Water sold by the inch by any individual or corporation shall be considered equal to an inch square orifice under a 5-inch pressure, and a 5-inch pressure shall be from the top of the orifice of the box put into the banks of the ditch to the surface of the water; said boxes or any slot or aperature through which such water shall be measured, shall in all cases be six inches perpendicular, inside measurement, except boxes delivering less than twelve inches, which may be square, with or without slides; all slides for the same shall move horizontally, and not otherwise; and said box put into the banks of the ditch shall have a descending grade from the water in ditch and not less than one-eighth of an inch to the foot."**

In other states, statutory inches have been recognized, generally being a development of a practice that arose among miners, and thus has been frequently called a "miner's inch." Thus in

Nevada it represents the flow through an orifice two inches high, with a head above the opening, of six inches. In other cases, the head has been four inches, six inches, eight inches, and sometimes the opening is extended to the surface of the water and no pressure is used. The whole area of the opening is then counted as "inches" of water. In this system, an opening six inches high and sixteen inches long would be, for example, 96 inches, and one six inches high by eight inches long would be 48 inches. If the system met the proper conditions of unit, the flow through one opening should be twice as much as the other. As a matter of fact the one opening will give considerably more than twice the other. This is due to the fact that the retardation by the sides of the opening from friction is relatively greater in the smaller one than in the larger. There are other conditions also, which may affect the quantity materially. The law does not prescribe the size or fall of the channel bringing water to the boxes, nor how rapid shall be the descent away from it—only providing that it shall be not less than one-eighth of an inch to the foot.

In some cases the term, "customary inch" has been used, and generally has represented the area of the cross section of the channel in square inches. This leaves out of account the rapidity of flow, which is of exceedingly great importance. In one water district in this state, the decrees of the ditches, has been expressed in "customary inches," a term which has not been convertible into definite quantities. It contains the germs of serious disputes, for while it may be expressed in cubic feet per second, the results would not be accepted without much objection.

Fortunately a better understanding of the objections to the "inch" has become wide spread, and the attempt to measure in inches is very rarely made. In California, a statute was once passed defining the inch in terms of its ratio to a cubic foot per second, and the inch under their conditions, was defined as 1-50 of a cubic foot per second.

In the ordinary form, an inch describes a method of measurement rather than a quantity of water. There is a common impression in this State that a Colorado Statute provides that 38.4 statute inches is the equivalent to one cubic foot per second. This is a mistake, for no statute has fixed this or any other ratio. As a matter of fact the ratio may vary all the way from 35 to 44. The basis for this impression seems to be a statement made in the second annual report of the State Engineer in 1884.

The State laws widely provide that in the statement of appropriations, the quantity shall be given in cubic feet per second. Notwithstanding this, the decrees in some districts have been given in other terms. This term, "cubic feet per second," is often ex-

pressed as "second feet," and now the term, "Cusec," a term originating in India, is making way by its brevity.

DIVISORS.

A division into a definite fraction can rarely be exact, but frequently, the convenience of an approximate division more than counterbalances any inaccuracy there may be. If the water is to be divided into two equal portions, by placing the two lateral ditches in identical relations to the main ditch, in a straight and uniform channel, the division is exact. Emphasis should be paid upon the *identical* relation, for many divisions are seen where the conditions are not the same, as, e. g., one branch continues straight, the other may make an abrupt turn, one may pass through a covered box, etc. In these cases some advantage is given to the ditch having the freer discharge. The effect of these differences is greater than is generally supposed. It is, however, generally not difficult to meet these conditions if the parties desire. By repeating the process, the water may be subdivided into four, eight or sixteen parts. But where it is required to divide the water into two unequal, or into three or more portions, equal or not, the division becomes one of approximation only. The difficulty arises from the fact that the water has not uniform velocity across the whole channel. The center has greater velocity than that near the banks. If, therefore, equal openings be made across the channel, those near the center have the greater discharge. Making the central openings smaller only partially avoids the difficulty, for as the relative velocities of the center and sides differ with different quantities of water in the ditch, this arrangement would still be inexact for any depth except that for which the adjustment is made.

In its most common form the divisor consists of a partition dividing the channel into two portions. These portions are usually inexact in proportion to the respective claims. This, in effect, assumes that the velocity is uniform across the whole cross section, which is not the case, even in a uniform channel, and much less so in one irregular or in poor repair. Such a division is to the disadvantage of the smaller consumer. This is commonly the case in the divisors used in Colorado.

The improvement in the ordinary methods of division is to make the velocity uniform across the channel. This is brought about in several ways. Sometimes by putting a board or drop at B-C, (fig. 1), making the division at the water drops over a weir; sometimes by increasing the width of the channel above B-C, so that there will be a still pool or reservoir, which will bring the water approximately to rest, and sometimes by a stilling-board, and sometime by making two or three such drops or falls. The purpose of all is the same, and that is to make the velocity of the

water uniform across the entire section of the ditch. Great pains are taken in some of the old Moorish boxes in Spain, the methods running back for centuries. Special care is taken to make the ditch straight for a distance of 50 or 100 yards above the point of division, paving the sides and bottom and increasing the cross section so as to lessen the velocity. In such cases the division is made quite exact. The principal error is then most likely from the difference in the freedom with which the water passes down the main ditch and enters into the side channel. If there be a drop at B-C, the effect from this cause may be neutralized or made insignificant. If there is no drop at B-C, the retardation in the lateral channel may have considerable effect and the change in favor of the main channel may be quite noticeable.

In some cases, however, this is just, for the users who receive water farther down the channel are subject to greater losses. If equal owners are to receive equal amounts then the user nearest the head of the canal should be given less than the amount proportional to his interest to allow for loss in carriage for the greater distance. Whether this is the proper basis of division depends upon the understanding of the users, and very possibly would be different in different ditches. The users only can determine whether the individual is to bear the loss of carriage to his headgate, thus giving advantage to the upper user, or whether this loss is to be shared by all. The special circumstances of each case may determine which is the just principle for that ditch, depending on the method of construction, the history of the development and the understanding.

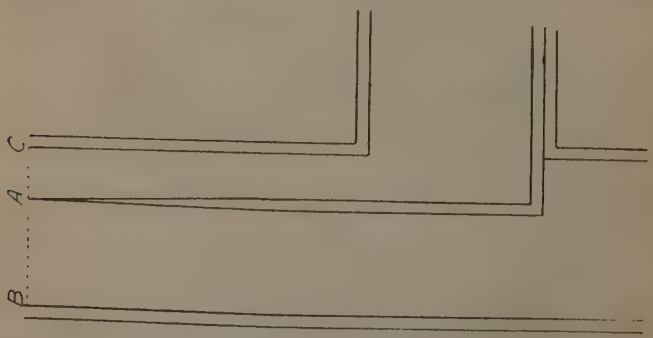


Fig. 1.—A Common Form of Divisor.

Figure 1 represents one of the most common forms of divisors. The partition board A is movable, and may be placed at different distances from the side C, so that the user can vary the proportion

of water which he receives. A cleat of some kind is often used to prevent the board from being moved beyond a certain limit. Where the ditch is wide and shallow there is sometimes a simple truss used, with a depending cleat. Sometimes a wire or chain restricts the movement. In these cases it is assumed that the amount of water going to the side channel is in proportion to the distance the movable partition is from the side, and the ratio is the same to the distance across as the volume is to the volume in the whole ditch. This is not, in general, true, because the velocity across the cross-section is not uniform.

Sometimes where this is recognized, and it is necessary to make close division, the water is brought to a state of approximate rest, or to a state of approximate equal velocity throughout the channel. In the case of some divisors, as in one seen on the Farmers' Union Ditch, in the San Luis valley, a weir-board over which the water drops is placed above the division board. This secures an approximate equality. The fall below the point of division should be sufficient to prevent the backing up of the water.

If water is brought to a complete state of rest, or very nearly so, and flows over the weir without lateral contraction, this method will give as satisfactory results as any divisor with which I am acquainted. An increase in the size of the ditch just at the division box will aid in bringing the water to rest. Boxes of this kind were used by Hon. J. Max Clark, of Greeley, as early as 1867.

The divisor which is in use at Elche, in Spain, is one which has developed from their conditions in that province. At Elche there is a peculiar system of water management. The water is owned independently of the land. The amount available is divided into a certain number of shares, and the use of each of these for twenty-four hours is sold each day in the market place to those who want water. In consequence the amount which enters any lateral varies from day to day, and the method of division requires a convenient way of varying the proportion.

Where the division is to be made, the sides and bottom of the canal are made of cut stone for a distance of about fifteen feet. There are two falls in the canal of twelve to sixteen inches respectively, about five feet apart, the upper one being about seven feet from the upper portion of the masonry. The canal for a distance of 150 to 200 feet above has little or no fall, so that the water reaches the first fall with almost no velocity, and passes over undisturbed and perfectly smooth. Furthermore, there is no contraction at the ends, so that the discharge is nearly in proportion to the length.

The arrangement for making the division consists of a parti-

tion which is permanent masonry, and divides the canal below the falls into two channels. At the upper end of this partition is a movable piece of wood coming to a point which is pivoted to the end of the partition, and can be held so that its upper end will include any assigned portion of the channel within certain limits. The length of the beak of wood is made so that it reaches to the upper drop when in line with the axis of the partition. The beak is set so as to include the desired portion of the channel and thus remains for twenty-four hours.

A Masonry Regulator with Iron Gates, near Arles, in Southern France.

At Lorca there is a system of sale something like that at Elche, for a portion of the area under cultivation, in which the amount which enters any ditch may vary from day to day. A divisor which may be called a needle divisor is used. The same care is used in the preparation of the channel as in the previous one described. A permanent masonry partition is placed in the channel. The proportion which enters the lateral channel is varied by varying the relative width of the main and lateral channels. This is done by inserting or taking out a series of narrow boards placed vertically. These are of uniform width. They are held in place both at top and bottom, and are carefully fitted to prevent leakage. The stream

is to be divided so that a certain number of hilas, according to the result of the sale, may enter the channel. No account is taken of the difference introduced by contraction. The discharge is assumed to be proportional to the size of the opening. The same principle is used occasionally in Colorado. One divisor near Greeley divides into four channels. It is not so good as the old Spanish ones because of neglect to look after details. The value of the water now justifies a considerable expense in a permanent divisor.

Time Method of Division.—On small ditches or laterals where the amount of water is not too great for one user to manage, and especially where the flow is uniform or nearly so, a time method of division may be used to advantage, and gives a more equitable division than boxes of the types described. Besides it allows the use of water in large enough quantities to make the use much more economical. For when a stream is divided it often happens that the parts are too small to accomplish much. It thus becomes desirable in almost all localities in times of low water to arrange so that one will combine the streams of several for the time during which he is irrigating. There is then some prospect of doing some good. The time method of division is especially applicable to small ditches where the amount of water is small. In such case the exchange is systematized. Each one takes the whole stream of water for a time proportional to his share in the ditch. The period is usually so arranged that the rotation will be completed in some definite time, as a week or two weeks, or such other time as the experience of the locality has shown to be desirable for an irrigation to be repeated. The water will then be given out at night or day according to schedule, and in order that the inconveniences may be fairly distributed, the period of rotation may be made to include a fractional day, so that those whose turn comes in the night during one rotation come in the day during the second, and vice versa. Thus, suppose the period of rotation be taken as one week, or for reasons above given, 7 1/2 days, and the number of shares be fifteen, of which some own one, others two and some three shares. In this case each share would give its owner the right to use the water for one-half day, or twelve hours; the owner of two shares would be entitled to its use for twenty-four hours, and the owner of three shares to thirty-six hours. Where there are a large number of rights or of users the same period would be carried out, but to a greater extent. As carried out in the countries where it is applied, the division is sometimes carried out to minutes. A time table is prepared at the beginning of the season, and each is furnished with a copy of it. The water is shut off or turned on the different gates according to schedule. The user must be ready to take

it at the proper time or lose the water until his turn at the next rotation.

This method is best applicable evidently in the cases where the amount of water flowing into the lateral is constant. This is rarely the case for the main ditch, and consequently the small laterals, are affected by the fluctuations of the main stream, shown in Bulletin 55. Where water is distributed from reservoirs, then the flow may be kept uniform. The necessity for restriction to certain times is distasteful to many. But by common consent, methods are used which are leading to this system. With the increasing pressure for the greatest benefit from the amount of water available this method will gradually extend in use under the conditions where it is best adapted. With the varying streams and varying flow, the method is not so equitable as the division of water as it comes. It is already becoming customary in ditch administration in Colorado, to keep records of the amount of water which is taken into the canals. It will become increasingly desirable and even necessary. For the larger ditches the amount of water which is taken into the ditch for different depths, is officially determined by the state engineer or his deputies. A similar rating of the lateral ditches may be made, or weirs may be used with greater accuracy. It will be possible to use a modified time distribution, so that each will be given the water long enough to give the same quantity. The unit could be varied, so as to bring the irrigations a convenient time apart. The successful operations of such a system would require an intelligent superintendent, who has the confidence of the users, and a wide-spread knowledge among the users.

In the distribution of water from small reservoirs, where there are but few interested, and where the different owners do not care to use the water at the same time, some such arrangement is necessary. With the weir measurement it is possible to keep account of the amount used by each person, so that the water may be divided in proportion to the rights of each.

This practice is spreading, and it is found that where once begun it is rarely abandoned. Within its own limitations it is an excellent method.

MODULES.

It is not possible to secure a module satisfactory in every respect or to meet all conditions. The following are desirable conditions which should be met by a module. Most of these conditions were recognized centuries ago by the magistrates of Milan. Some are manifestly of different importance.

1. **Its discharge should be capable of being expressed in cubic feet per second.**

2. The ratios of the discharge between two outlets should be correctly given by the module.
3. The same module should give the same amount of water wherever placed.
4. It should be capable of use both in large and in small canals.
5. It should be capable of adjustment so as to discharge any fraction of its capacity, and thus be used in distributing water pro rata
6. Any tampering should leave indications easy to recognize.
7. It should be simple so as to be operated by ordinarily intelligent men.
8. It ought not to require complicated calculation.
9. It ought to occupy a small space.
10. Its discharge ought not to be materially affected by fluctuations in the supplying canal.
11. Its cost should not be great, nor ought it to require much fall.
12. It not to be easily put out of order, and if so, the indications of its inaccuracy should be easily determined.

These conditions are evidently not of equal importance. Some may be dismissed; the first conditions become increasingly important.

The question of expense mentioned in No. 11 is a relative one and may or may not be of importance. As before pointed out, it becomes of less importance as the development of the irrigated section becomes greater, the need for accuracy more felt, and the value of water greater. The conditions that a small amount of fall be required is a physical condition which sometimes is impossible to meet. Often land lying close to a canal is to be served when probably no fall is available. For those places, special modules may be required, or special methods. The conditions that calculation ought not to be required may become of no particular weight when suitable tables are provided.

The condition No. 10 is one which is of more importance to ditches where equal division is made among the users. It is not of much importance in the larger canals or in those which have a ditch rider or patrol who can frequently adjust the gates. It sometimes is of importance for canals which have special contracts. It is a condition which has generally been considered the most important in the early stage of measurement from canals. In almost all countries, the first attempt is to give orifices of equal size to equal users, and then to make the quantity discharged by these equal orifices the same. To do this it has been necessary to keep the pressure of water on these orifices the same. Hence the module of Milan, the miner's inch of the various states. This condition is now less important. In our practice it is rarely attempted to make the discharges absolutely constant, but rather to perfect devices which can be adjusted by the frequent visit of the ditch rider.

The devices for maintaining a constant flow are essentially of two classes. First; those which attempt to maintain the pressure

of water constant with the orifices unchanged. Second: Those which vary the size of the opening.

Nearly all modules are of the first class, as the difficulties are simpler.

One was used on the Isabella Canal of Spain, of the second class, which seems to have been satisfactory. The old Italian modules, the miner's inch of the western states, is of this class. There have been many different kinds of openings, but in all, the principle was essentially the same. In the Soldati module of Milan, dating from 1585, an attempt was made to maintain the depth of water over orifices constant, by the use of a second gate and a regulating chamber. The orifice was on the lower end of the regulating chamber and the gate between the canal and the chamber would be raised or lowered so at to maintain the water to constant height. This same device has been used in some boxes in Colorado, especially in the one formerly known as the "Max Clark box," but now rarely used. It is an automatic device. If the gate is left unregulated, the flow from the orifice will increase or diminish in exactly the same ratio as if it came from the main canal. Its convenience is in the use of the regulating gate. The gate needs to be regulated with variation in the level of the supplying canal. This principle has been worked out with many variations in Italy and has led to the adoption of a complicated box with many accessories so as to still the waves, to lessen the velocity, etc.

A serious objection to this form is in the supposition that the discharge is in proportion to the size of the opening. It was natural to suppose that doubling the size of the opening would double the amount of water, and this supposition runs back to the earliest Roman times. The attempt to keep the flow uniform reduces the inequality but does not cause it to disappear, for while the fluctuation in the head in the second chamber is not as great as in the canal itself, yet the fluctuation in quantity in the lateral is as great as in the opening coming from the ditch itself, for the opening is correspondingly larger. The value of this principle as a regulator is therefore apparent rather than real. Its principal value is in the second regulating gate near the canal, and the fact that it is possible thus to choke or regulate the quantity received from the canal into the regulating chamber. However, unless such a box is regulated with every variation in the level of the supplying canal, it does not furnish a constant flow, which has been one of its supposed principal merits.

This box, however, represented a great advance in the practical measurement of water for irrigation purposes. It was brought forth after the great inequality in the division of water was rec-

ognized in the sixteenth century and was adopted in 1585. However, the interference this was supposed to cause with vested rights led to great trouble and to the condemnation at that time of Soldati, who proposed and urged it, though it is now recognized as having been essentially just.*

Experience showed that the discharge of the Milanese module was not in proportion to the nominal discharge. A person, for example, who drew one hundred oncia received more than ten times as much as the one who drew ten. It was, therefore, soon provided, that the discharge through any one orifice should not exceed a given number of oncia, generally six. The oncia varies from 34 to 47 liters per second, according as the orifice discharge from one to six oncia. A similar variation is true of the statute inch in this state. The advantage is entirely in favor of those who draw the large quantities.

There are other causes of variation, as in the distance the opening is above the bottom of the box, in the thickness of the sides, in the manner of its discharge. All of these render this module inaccurate and unreliable and is leading to its abandonment.

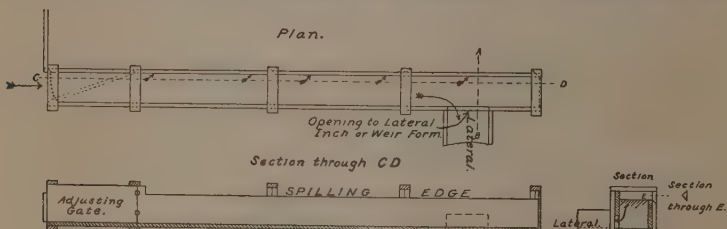
A module based on an entirely different principle was used on the Marseilles Canal in France and described in the earlier editions of this bulletin. This module consisted of a hollow vertical cylinder kept at a constant distance below the surface of the water by a float. The cylinder passed through a water-tight packing. It was noted in Bulletin 13 that this module would probably be insensitive. On a personal visit to the Marseilles Canal, it was learned that it had been abandoned for that reason. A modified form was attempted in Australia, where the connection was made by a bellows arrangement of leather. These and many other devices have been proposed, but do not seem to be especially valuable. It has been proposed to use a form of Venturi meter, a device invented by Clemens Herschel. The present objection is to the cost. A modified form of this has been proposed by Mr. R. G. Kennedy, of India, in an attempt to meet conditions given to him by the writer.

Other ways of modifying the size of the opening have been tried. In one, the water passed through a hole in which was a plug of metal, which was lifted by a float. The hole was circular. The diameter of the plug varies at different points, so that the size of the opening reduced as the head increased. In this case there is little or no friction. It is mentioned as an illus-

*The history of this event and the trouble arising therefrom is given in Bruschetti's Storia del Irrigazione del Milanesi, in his complete works, Vol. 2, pages 118 to 135. It is condensed in Buffon's des Canaux d' Irrigation d' Italie Septentrionale.

tration of a type more ingenious, however, than valuable, though it has less objection than some of the others. It would also require, like the Marseilles module, a considerable available fall.

A satisfactory means of preserving a constant head from a lateral is known as the spill box, or excess weir, which has been used somewhat in this state. This is an attempt to maintain the head constant and thus to give a constant flow. Any variation in discharge is caused by varying the length of the opening. It has been used in this state for the discharge of water in terms of the statute inch, and thus requiring the statutory head. It, however, could be used to deliver water by the weir method, and especially with the trapezoidal weir. The device is really a method of preserving a constant head. In the case of a small ditch, as



Plans of the Spill-Box.

shown in the figure, gates are located so as to force water into the spill box. On the side next to the lateral is a long sharp edged board whose crest is at the required height above the bottom of the opening. The length is such that the excess water spills back to the lateral. The sensitiveness depends upon the length of the box, and upon the regulation of the gates. It requires a sufficient available fall in the ditch so that the water will drop back into the ditch.

As made in the San Luis valley, the spill box is about 16 feet long. It generally requires a fall of about a foot. By making the crest longer, the device may be made more sensitive. As used in the San Luis valley, a hinged gate was used instead of the board and sometimes the boxes were used in pairs, as shown in Figure. This did not change the principle but saved expense in structures. The principle was first brought out by A. D. Foote, now of Grass Valley, Cal., and adapted to needs of canals by W. H. Graves, then of Monte Vista.

THE WEIR MODULES.

The form of module which is the most accurate is the weir or overfall. The knowledge of the flow through this, as through any other opening, depends primarily upon experiments previously made

and upon the certainty that it was placed under the same conditions.

There are, nevertheless, several different types of weir, any one of which may be used satisfactorily. The important condition is that it should be placed under conditions duplicating those of the original tests. It is simple, does not easily get out of repair, and can be easily tested. It is, therefore, making its way steadily as the most satisfactory form of measurement. In Colorado, in

A Double Spill Box—On a Lateral of the Monte Vista Canal Where It Crosses the Rock Creek Ditch.

This shows the spilling of the excess water, when more than the required depth.

the West in general, in Australia, India, Italy, Alberta and British Columbia, it is the measurement most generally used. The Cippoletti or trapezoidal weir is a special form of weir proposed in order to avoid one of the difficulties found in the introduction of the rectangular weir.

Practically all forms of weirs are based upon the experiments of J. B. Francis at Lowell in 1858.* His experiments are an instance of the value of careful work for though there are many attempts to develop other formula, all such formula are based upon his experimental results. His experiments were made to determine a better measurement of water suitable to the needs of the manufacturing enterprises at Lowell with capital of millions of dollars. The stream was divided among these large users. This justified the expense needed to perform the experiments with care and with such attention to minute sources of error that they were above criticism. The same conditions have continued since the time of

*Lowell Hydraulic Experiments

Francis and experiments have continued at Lowell. While the subsequent experiments have not been published, a personal examination of the appliances seems to show that there might be much of great value. Tests were made by Mr. Francis of the flow over weirs and the water was measured in a large basin containing some 12,000 cubic feet. By taking account of the contraction at the sides and at the crest of the weir, Francis succeeded better in producing a formula which represented the discharge.

The equation assumed and agreeing closely with his experiments is given with the form.

$$Q = aLH^{3/2}$$

Where Q is the quantity of water in cubic feet per second, L, the effective length of the weir in feet. It is not necessarily the same as the actual length of the weir. It is mentioned more fully on the next page.

a is a coefficient supposed to be constant. The limitations in length and depth state conditions within which it is practically constant.

H, the depth of water flowing over the weir, in feet. Because of the contraction, this must be measured far enough from the weir to be free from its influence. If the water approaches with a current, this depth needs to be increased by a correction indicated by theory. The object is to give the equivalent depth if the water came from rest. This correction is troublesome to make. In practice it is better to so check the velocity of the current that the correction will be so small that it may be neglected. Table H in the appendix gives the amount of this correction which is needed to multiply the results obtained by the indicated operations in the measured quantities, in order to give Q the discharge.

From his experiments, an abstract of which cannot convey an idea of the care and skill used in the experimentation, Francis adopted the value of 3.33 for a; 3⅓ would agree a little more closely, and is slightly more convenient for independent calculation.* The value of 3.33 is almost universally adopted. The difference in the results by using these two coefficients is one-tenth of one per cent.

The formula of Francis then becomes

$$Q = 3.33\ LH^{3/2}$$

or with the modification above mentioned, $Q = 3\frac{1}{3}\ LH^{3/2}$ where the letters mean the same as above and with the same restrictions. The first one is the one properly termed the Francis formula. The second one is the one I have used, based on his work and agreeing slightly better with his results.

Q represents the discharge in cubic feet per second.

L and H are both measured in feet and decimals, not in inches.

*The actual value from his results is 3.3318. He adopted 3.33. 3 1-3 is slightly more convenient for mental calculation and I have used it in the table in Bulletin 13 and since.

Sometimes it is convenient to make measurement of the depth in inches. Scales graduated in decimal parts of feet are not common. In such case the following formula may be used. Q is the discharge in cubic feet per second in both cases.

Where depth is measured in inches, and length of *the weir is given in inches,* then

$$Q \text{ (sec. ft.)} = .0798 \text{ L (in inches) } H^{3/2} \text{ (in inches)}.$$

Where the depth is measured in inches, but the length is *given in feet.*

$$Q \text{ (sec. ft.)} = .006675 \text{ L (in feet) } H^{3/2} \text{ (in inches)}.$$

An additional word needs to be said regarding L.

L is the *effective* length of the weir, which in case of the rectangular weirs, is not necessarily the same as the actual length.

The various experiments made by Francis may finally all be classified and put in the following abstract:

SUMMARY OF FRANCIS' EXPERIMENTS ON WEIRS*

Depth has in all cases been corrected for velocity. Supply canal 14ft wide.

Serial Number.	Depth of Water on Weir in Feet	Coefficient for the Series	Length of Weir in Feet	Number of Contractions	COMMENTS
1- 4	1.56	3.318	10	2	SERIES A.
5-10	1.25	3.334	10	2	Crest of Weir is 5 ft. above floor of channel of approach.
11-33	1.00	3.322	10	2	
56-61	0.80	3.325	10	2	
72-78	0.62	3.328	10	2	
36-43	1.06	3.353	10	2	SERIES B.
62-66	0.83	3 340	10	2	Same as A except that crest is only 2ft. abovefloor.
79-84	0.65	3.326	10	2	
44-50	0 98	3.341	10	0	SERIES C.
67-71	0.80	3 339	10	0	Canal made same width as Weir Suppressing end Contractions. Otherwise as in A.
51-55	1.00	3.327	10	0	SERIES D. Water cannot expand after passing Weir.
34- 5	1.02	3.360	8	4	Water 5 feet deep.
85- 8	0 68	3.337	8	4	Water 2 feet deep. In both sets, two boxes separated by a partition 2 feet wide giving 4 contractions.

*The author of this bulletin is responsible for the summary and the classification in these series.

Comparison of series B and A shows the effect of nearness of floor on the vertical contraction.

Series C and D correspond to the cases where weirs are erected in the middle of flumes; C to the case where the weir is at the lower end; D where at middle.

These experiments have been made with such care that they are standard and are uniformly recognized as being results which can be used with confidence in discussions of the accuracy of the weir.

The greatest depth tested was about 18 inches, and the least 7 inches. Series A and B correspond to the ordinary cases. From these, Francis concluded that the coefficient to be used in the formula might be taken as 3.33 while the length L is not the length of the crest, but is less by an amount which increases with the depth of water over the weir. It is noticed in his trials that the length of the weir is less than the width of the canal, thus giving the conditions for what is termed a complete end contraction.

Francis presented his formula (i. e., with the constant coefficient) as being applicable to cases where the depths do not exceed two feet nor fall short of three inches, and where the depth over the weir is small as compared with the length.

Experiments have since been made at the Cornell Hydraulic Laboratory which show that this formula may be used without material error up to depths of four and even five feet on the weir, provided the other conditions are observed. In these cases the flow over these weirs has been measured by the discharge over rectangular weirs agreeing with the conditions fixed by Francis.

Some explanation needs to be made concerning the contraction of the stream and its effects on the flow. If water passes through an orifice it will be noticed that it becomes narrower at the opening and then expands. If it passes over a weir with a sharp edge, the sheet of water immediately below the crest becomes thinner. This is termed the vertical contraction. At the sides, it also narrows and then expands. This is spoken of as the lateral contraction. The amount of the lateral contraction becomes greater as the depth of water is greater. Francis attempted to take several disturbing effects into account in the correction to L.

While the correction is not entirely satisfactory, it is close enough for practical purposes so that the formula may be used with confidence, provided the weir is placed according to proper conditions. The amount of the contraction is also affected by the distance that the sides of the box are from the end of the weir. In Francis' experiment, the weir 10 feet long was in a box 14 feet wide. If the box were narrower and the weir the same, the side contractions would be less and the effect is to increase the flow somewhat. When the distance to the sides of the box is two or three times the depth of water on the weir, the contraction remains practically constant and is said to be complete. If the box becomes narrower, the contraction is incomplete.

The amount of this contraction when complete increases with

the depth of water flowing over the weir. It is difficult to measure directly. The tests to determine its amount were unsatisfactory and consequently weirs are sometimes made to eliminate lateral contraction entirely. On the assumption that the contraction is one-tenth of the depth the calculated discharge agreed so closely with the measurements as a whole that this convenient factor was adopted. If there are two contractions, one at each end, the reduction of length would correspond to one-fifth of the depth of water flowing over. With this assumption the flow may be found within one per cent. within the limitations given by Francis.

Thus we may take an example from the abstract of Francis' experiments on page 25. In the case of the serial numbers 1-4, the depth is 1.56 feet. There are two contractions, hence the effective length of the weir used in the calculation of the discharge, is not 10 feet, but 10 feet shortened by .31 feet (2, the number of contractions, x 1/10 of 1.56). The effective length to be used in the calculation is accordingly, 9.69 feet. With the same weir, in the series 56-61, the effective length is 9.84, though the length of the weir is the same in both cases.

It is because of the correction to the length in the rectangular weirs in the Francis formula that the weir method of measurement was slow in being adopted. It is evident that a weir twice as long as another will give more than twice as much water, with the same depth. This proved a stumbling block in the popular mind, and stood in the way of its use.

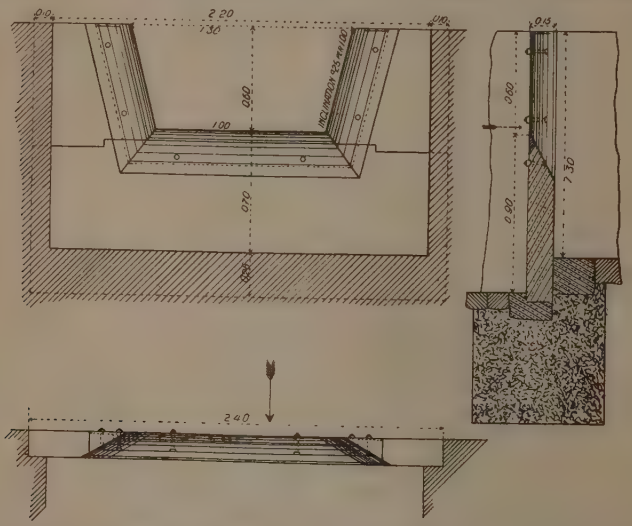
The advantage of the Cippoletti form of trapezoidal weir is that the discharge varies directly as the length of the weir, so that if one weir is twice as long as another, the discharge will be twice as great. This is a great practical advantage in its use on canals, because it helps to lessen the suspicion frequently met with.

This weir is one proposed by the Canale Villoresi, one of the great Italian canals in the valley of the Po. This canal was built about 25 years ago as a "high-line" canal to water land above existing ditches. It waters about 125,000 acres just north of Milan. In the permit to this canal, the company was required to propose a module based on the weir. The problem was put in the hands of Cesare Cippoletti, the engineer in charge of construction, who, from the experiments of Francis, attempted to determine a form of weir and conditions so that the results would be correct enough for ordinary purposes, and so that no single cause would produce an error of one-half of 1 per cent. This is often spoken of as a trapezoidal weir but because there are many forms of trapezoids, I proposed that the name of the engineer should be connected with it, in the first edition of the Bulletin, and it is now

very generally known in English speaking countries as the Cippoletti weir.

Cippoletti proposed to use a trapezoidal form with such angles that the increase in the flow caused by the triangular areas at the ends should balance the loss due to contraction. If this could be done, the correction for contraction is made automatically and the flow would be in proportion to the length of the sill. From the adopted coefficients of contraction it is found that this inclination would be practically one-fourth to one or three inches to one foot. This is not quite exact, but the difference is so small that it is convenient to use this for ordinary purposes.

I made some experiments on weirs of this form, but of small size, before the first edition of this Bulletin. Other experiments were made by T. V. McVickers under the direction of Prof. Church



The Cippoletti Trapezoidal Weir—Dimensions Based on Unit Length of Sill.

of Cornell University. The most complete ones were made by Messrs. A. D. Flynn and Dyer of the Worcester Polytechnic School or Worcester, Massachusetts, who experimented with weirs from three to nine feet long and with depths of 18 inches. These indicated that the average error was above the one per cent. indicated by Cippoletti, but that the discharge is in proportion to the length of the weirs. This is the feature which makes this particular form of weir valuable for irrigation purposes.

The weir measurement is accurate *provided the proper conditions are observed,* hence the importance of an understanding of the conditions and their careful observance, both in construction and in operation. The formulae are most reliable only within the limits set by Francis, that is, within depths ranging from 3 to 24 inches for complete contractions, and for weirs not much exceeding 10 feet in length, but subsequent tests show that they may be used for greater depths and lengths without material error. The theory of the flow of water under even more simple conditions is still too incomplete to make it safe to extend the formula much beyond experimental lines. Within these limits the coefficient may be taken as constant. Outside of these limits, the coefficients would probably require a different value. In the Francis formula, the coefficient is taken as constant.

In most cases weirs are not placed with sufficient care. On the Canale Villoresi, the weirs I examined were made of cut stone with cast iron plates used for the sides and sill. The value of water justifies the construction of permanent and substantial weirs in this State and much more pains than is generally taken.

Conditions.—The following conditions relate to both types of weir. When these conditions are followed, the formula above given and the tables attached to this Bulletin may be used with confidence that the result is correct within 1 per cent.

1. The channel leading to the weir should be regular, of constant cross-section, its axis passing through the middle of the weir, and perpendicular to it; this straight reach to be of such length that the water flows with uniform velocity, without internal agitation or eddies. This should be not less than fifty or sixty feet in length, more if possible.

2. The contraction should be complete on both sides and bottom. This is necessary that the coefficient "a" in the formula may be free from uncertainty. To secure complete contraction it is necessary:

(a). That the opening of the weir be made in a plane surface, perpendicular to the course of the water;

(b). That the opening itself have a sharp edge on the upstream face. For this purpose, if the thickness at the point of discharge is not more than one-tenth the depth for depths from 5 to 24 inches, it may be considered as sharp;

(c). That the height of the sill of the weir of the canal be at least three times the depth of water on the weir;

(d). That the length of the weir should be three, or still better, four, times the depth of the water flowing over;

(e). That the depth of water flowing over the weir be not less than 3 inches;

(f). That distances from the sides of the flume shall be not less than 2 times the depth.

3. The velocity of approach must be small. For weirs three feet long and depth of 12 inches, it ought not to be more than one-half foot per second; for weirs of six feet long and depth of 24 inches it ought not to be above 8 inches per second. In all these cases the cross-section of the canal of approach ought to be at least seven times that of the weir. Other conidtions affecting the velocity of approach are included in c, d and e in condition 2 above.

4. The layer of falling water should be perfectly free from the

walls below the weir, in order that air may freely circulate underneath. For short weirs it is sufficient that the lateral walls of the lower canal be free from the sides of the weir. In such case, when air freely passes underneath, the level of the water in the lower canal has no effect on the discharge unless it reaches to the level of the crest of the weir.

5. The depth of the water should be measured accurately at a point where the suction of the flow does not affect the level of the surface and where it is free from influences like the wind, or the movement of the water, which affect the true level. The height should be read to within 1-300 of the depth in order that the error may be within one-half of 1 per cent., or 1-67 to be within 1 per cent. This means to one-fifth of an inch when depth is one foot.

6. The weir needs to be carefully constructed. It should not vary more than 4° from being perpendicular to the channel. Its sill should be horizontal.

Table I. will aid in obtaining proper proportions between the channel of approach and the weir.

The conditions affecting the flow may be divided into three classes; those which always tend to increase the discharge, those which always tend to decrease, and those which may either increase or decrease, as the case may be, and thus in the long run, tend to balance.

The flow of the weir is decreased by eddies or by obliquity of the weir to the sides.

The quantity is increased by the velocity of the approaching water, by nearness of the sides to the end of the weir, or the bottom of the box to the crest, or by any condition which prevents a complete contraction at the sides or at the crest. If sand or silt collects in front of the weir board, this decreases the contraction and increases the quantity. If the water below the weir board backs up so as to prevent air from having access underneath the sheet of falling water, then the vertical contraction is lessened and the discharge is increased.

If the crest is not sharp or its thickness more than one-fourth of the depth of the water on the crest, the vertical contraction is lessened and the flow is increased. When the thickness still further increases the effect is to decrease the flow.

It is evident that the changes that are likely to happen increase the flow of water over that given by the formula. These are difficult to avoid and in general cannot be entirely eliminated. It is because of this that Cippoletti proposed to make an arbitrary increase of one per cent. in the formula. This is not necessary and it would seem to be better to use the ordinary Francis formula, making the weir as near perfect as possible and making allowance, if necessary.

The correction to be allowed to the tables may be estimated in some cases by the following considerations: If the weir is not vertical, the discharge is increased or diminished according as the in-

clination is down or up stream. For inclination of 45°, the effect is to cause a decrease of 7% if it be up stream, and an increase of 10% if down stream. For less inclinations, the correction is correspondingly less, being less than 4% if the slant is not over 18°. It is easy to maintain practically vertical.

If the box or channel of approach is narrower than required by condition 2f, the flow is increased. If the width is reduced to 1 1/2 times the depth, the flow is increased by about one-third of one per cent. and still more if narrower.

If the condition 2c is not complied with, the increase amounts to one-half of 1 per cent. if the distance of the sill from the bottom is reduced to 2.5 times the depth of the water over the weir; and the increase amounts to 1 per cent. if this height is reduced to two times the depth; 1 1/2 per cent. if it is equal to the depth; and 2 per cent. if it is one-half the depth. This is the height of the sill above the bottom on the up stream side. If filled in with sand, the surface of the sand should be considered as the bottom. Table II. in the appendix gives means for estimating the effect for any other depth.

The temperature of the water has a slight effect, but for all ordinary conditions may be neglected. An increase of temperature seems to increase the discharge through action of the surface tension of the liquid. With large openings, the effect is less than with small openings.

The velocity of approach is, all things considered, the most difficult to reduce within reasonable limits. These errors are the most difficult to allow for and they are the source of the most considerable errors under ordinary conditions. It is not possible to entirely prevent some velocity in the approaching water. It is desirable, however, to cause it to flow from rest as near as possible. The velocity is reduced by increasing the size of the approaching channel or by making a basin in front of the weir. This is sufficently reduced by making the cross-section of the basin seven times as great as the opening of the weir.

When this is the case, the effect of velocity of approach may be neglected. For many cases this cannot be entirely prevented. Often the greatest trouble comes from sediment in the water, which is deposited in front of the weir board. Thus, even if the weir has been placed originally under proper conditions, the effect of the silt may be to change those conditions and cause the weir to be unreliable. In some streams the trouble is serious, and almost prevents the use of the weir. It can usually be met by arranging the weir board so that it may be raised and flush out the sediment. The ditch rider should understand the effect of the silt, and that the discharge under those conditions is greater than would be indicated by the tables.

It is troublesome to compute the allowance for velocity of approach. The better way is to avoid the necessity by keeping within the bounds indicated by condition No. 3, page 29. If correction needs to be made then use tables I. and II. of the appendix which are prepared to aid in making the correction.

The following method due to Fteley and Stearns I have found to be satisfactory and easily used.

The correction for velocity of approach may be made by using $H+\frac{3}{2}h$ in place of the measured depths in the weir formula, $Q=3.33\ LH^{\frac{3}{2}}$ instead of H as the depth to be taken. Where $h=V^2\div 64.4$; V being the average velocity in the canal found by dividing the quantity by the area. All expressed in feet. It gives a much larger correction for velocity than is furnished by the Francis correction, but it agrees much better with measurements I have made for high velocities. The experiments on which Francis' formula was based were limited to velocities of 2.5 feet per second. Table II. gives the per cent. increase in discharge caused by different velocities. It will be seen how great this correction becomes, sometimes causing an increase of several hundred per cent., and consequently shows the importance of keeping the velocity within low limits.

To aid in the practical allowance for velocity of approach, two tables have been prepared and are printed as tables I. and II., of the appendix. Table II. shows the allowance in per cent. to be made to the quantities given in tables III. and IV. The increase with a given velocity varies with the depth of water over the weir, being greater for small depths. A velocity of one foot per second increases the discharge over a weir when the water is flowing three inches deep, over 14 per cent.; if flowing over the weir one foot deep, only 3.5 per cent. Table I. shows the average velocity as the water passes through the weir, or it shows what is the velocity in the channel if the section is the same as that of the weir, as it frequently is. A comparison of the two tables will show the proper section to give the channel in order that the resulting error shall be within reasonable limits.

If condition No. 4 is not met, there is an appreciable increase in flow.

The effects of the conditions already given are sufficient to show that the conditions increasing the discharge are more numerous and more difficult to remedy than those which have the opposite effect. If there has been carelessness or ignorance in placing the weir, it would commonly be shown in making the weir too low or making the opening too long compared with the width of the basin or canal above the weir, or in allowing it to silt up, the effect of all of these is to increase the discharge. Likewise, if the crest

of the sill is not sharp or is slightly rounded on the upstream side, there is an appreciable effect. A serious fault of the weir is, that carelessness in making or neglect in maintaining it, tend inevitably to increase the discharge. It is not to the interest of the consumer to see that the proper conditions are maintained.

The measurement of the depth of the water is difficult to make accurately. Frequently this is done by placing a post some distance above the weir and the depths measured on it. This should be at least six feet above the weir. As the water is constantly subject to fluctuations this can not usually be done with sufficient accuracy. The best place to measure the water would be in a well to one side of the basin and connected with it by means of a small tube. This well may be nearer than six feet to the plane of the weir because the pressure of the water will bring the water level with the surface further up stream. It should be from 3 to 12 inches in diameter or square, depending on how it is to be used. A float may be made with an arm extending above the surface graduated to read zero when the water is level with the crest of the weir. The rules commonly to be had in the market are for the use of mechanics and divided to 16ths of an inch. Rules divided to decimals of a foot would be better for this purpose.

These conditions all pertain to the rectangular weir, as well as to the trapezoidal. The Cippoletti or trapezodial form of weir is simply different in the form of the opening. It has been shown that the side contraction is greater as the depth of the water over the weir is greater. The broadening of the opening is such as to automatically allow for that contraction, so that the calculation is based upon the length of the weir without allowing for contraction.

SUBMERGED OR DROWNED WEIRS.

Many times the water backs to or over the crest of the weir. This is sometimes accidental, and sometimes is due to the fact that it is necessary to run water on land close to the main canal without sufficient drop. While it is not desirable to depend on submerged weirs, as these are called, yet within moderate limits the results of such weirs can be depended on and the ordinary tables used.

The first effect of backing over the crest is to increase the discharge, because the air underneath the falling sheet is displaced and the air pressure tends to increase the amount more than the decrease due to the discharge under water. Then when the submergence is about one-seventh of the total head, these effects balance and the discharge is again the same as that given by the tables. With greater submergence there is more decrease, so that when the submergence amounts to one-quarter of the head the discharge

is decreased by 5% and only by 10% when the submergence amounts to 40% of the head.

The various formulae for submerged weirs are not satisfactory, partly because they call for accurate measurement of the submergence, which is difficult and untrustworthy. The table here given of the corrections to be applied to the ordinary weir tables does not call for any close measurement and thus it enables the submerged weir to be used in many cases with fair satisfaction where it has been considered inapplicable. The amount of backing up can usually be told within moderate limits. Whether, for instance, this submergence is 25% or 30% of the total head makes little difference; the correction to the tabular value is 5% in one case and 6% in the other. With greater amounts of submergence the error in estimating would bring in greater variations in the estimate of the discharge, but we are then approaching conditions which it is generally possible to avoid.

SUBMERGED WEIRS.

Corrections to apply to the ordinary weir.

$\frac{h}{H}$	Correction per cent.	$\frac{h}{H}$	Correction per cent.	
.01	+0.6%	.45	—13. %	
.05	+1.0%	.50	—16. %	H is total head over weir.
.10	+0.7%	.55	—19. %	h is amount of back water
.13	0.0%	.60	—22. %	h ÷ H is proportion of depth or head, expressed decimally, which is back water.
.15	—0.6%	.65	—26. %	
.20	—2.0%	.70	—30. %	
.25	—5.0%	.75	—35. %	
.30	—6.0%	.80	—41. %	
.35	—9.0%	.85	—48. %	
.40	—10. %	.90	—56. %	
		.95	—68. %	

+ or — indicates whether the correction is to be added or subtracted from the tabular values of Tables III to VI.

Example of the use of the table: The water on a weir is 12 inches deep, but the weir is drowned to the depth of 3 inches. What is the discharge, the other conditions being good and the weir 3 feet long.

An ordinary weir for this case would have a discharge per table IV., of 9.99 second feet. Here "h" is 25% of H and the correction is 5%, to be subtracted, thus giving a result of 9.49 cubic feet per second.

By using this table it is possible to make use of the weir in many laterals where there are not good conditions for the ordinary weir.

WEIRS NOT LEVEL.

From settling or other causes it sometimes happens that weirs are not level, and it may be necessary to get the best results possible for the time being. The tables may be used for that purpose with a small amount of calculation by the following formula: H_1 and H_2 are the depths at the ends of the sill, H_1 being the greater; Q_1 is the quantity for the depth H_1 with a weir of corresponding length, obtained by the use of the tables, and Q_2 is the quantity if the depth had been H_2. Hence in such case, find the discharge

corresponding to the depth at each end by the use of the tables. Multiply each of these quantities by the corresponding depth; subtract these two results and divide by the difference in the depths of the two ends, and take 2/5 of this quotient. The depths should be expressed in decimals of feet.

$$Q = \frac{2}{5}\left(\frac{Q_1 H_1 - Q_2 H_2}{H_1 - H_2}\right)$$

THE TRIANGULAR WEIR OR NOTCH.

A weir in the form of a triangular notch can be used in many cases to advantage. As the perimeter always bears the same ratio to the area the friction remains constant for different depths. This notch does not seem to have been used practically. It, however, might be used to a greater extent for laterals from canals. For that reason table II., the first of this kind that I know of, is given for a right angled notch that will enable it to be used.

The best form of notch would be a right angled notch with the corner downward. For a depth of one foot it will give a discharge of 2.5 cubic feet per second, which is as much or more than an ordinary lateral takes, and consequently may be used for that purpose. It is not applicable for large discharges.

The equation for the flow through such an opening is:

$$Q = 15m\ T\sqrt{g}\ h^{5/2}$$

where m is the coefficient of contraction, T the tangent of one-half the angle, G the acceleration of gravitation and H the depth. Giving M the value 0.592, the formula becomes:

$$Q = 2.54\ Th^{5/2}$$

where Q is the discharge in cubic feet per second and the head on the notch is measured in feet. This should be measured at a point several feet upstream from the notch, the same as in the case of the weir.

If the notch is a right angle notch we then have the equation of discharge: depths in feet.

$$Q = 2.54\ h^{5/2}$$

As this notch is especially adapted for small discharges it would be best adapted to conditions where the water is not over 12 inches in depth. It is then convenient to be able to express the quantity in cubic feet per second, with the depth measured in inches.

In this case the discharge in cubic feet per second would be:

$$Q = .0051\ h^{5/2}$$

where h is in inches.

This notch should be placed to conform to the conditions of the weir, that is, it should be placed at right angles to the current;

the edge should be sharp on the upstream side; it should be at some distance above the bottom of the channel; the two sides of the weir should be equally inclined to the vertical and there should be free flow of the water away from it. The point of the notch would not need to be as much above the bottom of the channel as the ordinary weir.

RATING FLUMES.

Weirs can not be conveniently used to measure water into canals, or even into large laterals. The fall required makes them inapplicable in most cases. Hence the method used is some form of rating flumes. These are recognized by law and the state officers may require them to be constructed.

A rating flume is commonly a flume built in the ditch some distance below the head gate with a rod graduated to show the depth. Measurements are made with a current meter to determine the quantities at several depths, and tables may then be prepared which will show the quantity at intermediate depths. There should be at least four such guagings made. If the conditions are good the results when plotted to scale, fall on a regular curve, and from that curve the quantities for intermediate depths may be taken with considerable confidence. A table is then prepared giving the quantities for different depths, and especially indicating the depth required to give the various appropriations of the canal. I have agree within one per cent.

The results depend on the skill of the gauger, on the accuracy of his meter, and the skill exercised in its "rating," and then on the conditions of the rating flume so that conditions are essentially the same at different times for the same depth, and there are no irregularities in the flow.

The flume should be far enough from the head gate to avoid the rush of the current which sometimes may be felt for considerable distances when the stream is high and the gates nearly shut; it should be in a straight reach of the canal, so that the current is central in the canal and free from eddies or boils due to roughness; it should not fill up with sand in some stages, to be scoured out at others.

The purpose of the flume is primarily to secure a constant bottom and cross section. Often this may be done by a simple construction, or even in rocky channels by one or more timbers across the bottom of the canal to fix the points of reference. It is common to make the sides of the flume vertical. In large canals or where the velocity is great, this may cause a considerable perturbation or contraction in the current. Hence I have sometimes caused such flumes to be built with the sides flaring so as to correspond to the slope of the canal bank, and thus the water passes

through smoothly and without ripple. In such cases it is desirable to measure the depth in a well of still water connectly freely with the water in the flume. Without some such method the results are often discordant.

The results with fairly moderate quantities of water ought to be correct within 5%, and with proper care in construction of weir and its rating, to still less error. It is not so reliable for smaller channels and smaller quantities, but still may often be used with advantage where the weir cannot be used. One of the principal reasons why it is not adopted for measuring water to consumers is that the rating of these flumes calls for considerable skill as well as an instrumental equipment not frequently available. The errors in small ditches like laterals are also much larger than in large ones. Hence it is not to be used for this purpose, though for measurement into canals or into the larger laterals it may be entirely satisfactory. There may be reasons which force one to choose rating flumes as the last available method for the conditions, as, for instance, where sand or silt fills up the weir box, or where no fall is available. If there were enough need, I have no doubt that the rating flumes for small ditches could be developed so as to be nearly as accurate as the weir under the ordinary conditions. It would require special current meters adapted to the conditions.

COMPUTATION OF QUANTITY FROM THE SECTION AND FALL.

It is often necessary to determine the amount which a canal will carry, or to decide on the size required. For this purpose the formula commonly known as Kutter's is generally used. The results are to be taken with considerable latitude, and as will be seen are not exact enough to serve as a basis for division of water. These variations may be easily as much as 20%, and even then require accurate determinations of the slope of the water surface, (not the bottom of the canal) not commonly available, while the ordinary demands of the ditch call for accuracy within 5% or 10%.

The calculation by computation attempts to determine the velocity of the water, while the quantity, which is usually wanted, is the product of the velocity and the area of the cross-section. These should be expressed in feet-per-second, and in square feet, in order that the result be in cubic-feet-per-second which is usually wanted.

It is a matter of common observation that the velocity of water depends upon the section, upon the grade, and also upon the roughness. That is, given two canals of the same grade, the larger one will have the greater velocity. It is common observation that when a canal is enlarged it scours and checks must be built. The sides have a retarding influence somewhat in proportion to the

ratio between the cross-section of the channel, and the length of the line of contact between the water and the surface. This ratio is termed the "hydraulic mean depth" or the "hydraulic mean radius" and is represented in formulas by "r."

The velocity also increases with the slope or inclination which is represented by "S" or "i," and is the fall per 100 feet expressed decimally.

The relation between the velocity and the hydraulic radius and slope is not a direct one, that is, doubling the fall does not double the velocity. But to double the velocity, the fall must be four times as great, or the hydraulic radius four times as great as before.

The condition of the surface of the channel in contact with the water also affects the velocity, for where the surface is rough it is visibly reduced. While such a relation was perceived, the old formulae attempted to include the first two relations only, and became

$$V = c\sqrt{ri}$$

The coefficient "c" was given values based on what experience had shown as applicable. There were commonly three values of "c" used, for small, for moderate and for large canals, and the results were very unsatisfactory.

Some fifty years ago two French engineers with the aid of the government made an elaborate series of tests on a small canal where the conditions could be changed, and especially the surface of the channel. Darcy and Bazin were the names of these engineers, and from the tests, all on small channels, none over three feet wide, obtained the effect from varying the surface. They made a number of classes depending on the surface and produced a formula which is still extensively used by French and Italian engineers, The formula did not give sufficient guide to engineers to apply the formula to the numerous conditions arising in practice.

Kutter's formula is another step to determine the value of "c" to be used. It is based on the work of Darcy and Bazin, but attempts to express the complicated relations between this coefficient and the size of the channel, the grade, and the roughness (by introducing a coefficient of roughness), all of which have an influence. The relation is complex, but it is not necessary to give here as the value is always found by the use of tables.

The coefficient of roughness is represented by "n." It varies from .009 from smoothest boards to .035 for a rough canal in poor order. For most open channels with which we have to do in irrigation it is comprised between .018 and .030, or commonly between .020 and .025. The results obtained depend entirely on the selection of "n," and the choice of this requires knowledge of the value

under corresponding conditions. Under the best of conditions the result is subject to much uncertainty.

Thus the table gives the values of "c" for a few cases, and shows the great variation which comes with a different value of "n." Thus with a moderate sized ditch, hydraulic mean depth of two feet, the coefficient "c" would be 98 with "n" .017, and only 66 for "n" .025. One result is 50% over the other. These would be a difference of 27% made by selection of .020 or .025.

There is a very common inclination by courts and lawyers to accept any results by the Kutter formula as beyond question, but these show how much the result depends on the coefficient "n," and this choice can only be made with much reserve, and with knowledge of results of actual tests in similar conditions.

Nor does it follow that "n" remains the same in the same canal at different depths, or that it remains the same with the same depth for any length of time. Thus I have found "n" to vary from .022 to .027 in the same canal, the greater value of "n", and hence the smaller value of "c" with the increased depth. This was attributed to the fact that with the greater depth the water partially overflowed the bank and was retarded by underbrush. The growth of weeds during the summer often makes a noticeable effect on the carrying capacity of a canal for the same depths.

Hence, while the Kutter formula is of great usefulness, it must be used with intelligence, with a knowledge of its limitations, and realizing that the results under the best of conditions may be considerably in error. The expression for "c" in English measures is complicated, but this arises partly from the fact that it was derived in French measures, and the constants were simple in that system, but have become more complex in the transfer of units. Had the formula been derived in English units in the first place, or if some one should go to the trouble to obtain the expression so as to use English units, the apparent complexity would be much reduced. However, with the access to tables now easy, the engineers do not have occasion to use the formula itself, and this complexity does not matter.

It should not be forgotten that the whole purpose is to get "c" in the formula on page 38. Books like Trautwines Civil Engineer's Pocket Book have tables extensive enough for common use; other more elaborate tables have been prepared. The attempt to compute "c" to decimals is time wasted, for the error in the judgment of "n" may introduce a much larger error. Practically some forms of diagrams are accurate enough and much quicker to use.

VALUES OF "C" GIVEN BY KUTTER'S FORMULA.

	Fall 1.06 ft. per mile				Fall 2.11 ft. per mile				Fall 5.28 ft. per mile			
Roughness "N"	.017	.020	.025	.030	.017	.020	.025	.030	.017	.020	.025	.030
Hydraulic Depth ½ ft.	69	56	43	34	71	58	45	35	73	59	46	36
1 ft.	83	69	54	44	85	70	55	45	86	71	56	45
2 ft.	97	82	64	54	98	83	65	54	98	83	66	54
3 ft.	105	89	72	59	105	89	71	59	105	89	71	59
4 ft.	111	94	76	63	110	94	76	63	110	93	75	63

OTHER FORMULAE.

Attempts have been made with some success to develop formulae in which the coefficient is constant for the same class of channels, irrespective of size and slope, but with varying exponents of "r" and "i," not constant as in the one on page 37. Such are Sullivan's, Tutton's, the Williams-Hazen, where the exponents of "r" are 3/4 in Sullivan's, 2/3 in Tutton's, 0.63 in W.-H.; and the exponents of "i" 1/2 in both Sullivan's and Tutton's, and 0.54 in W.-H..

These formulae give much promise but are not convenient to use without tables which are not available execpt in the case of the Williams-Hazen,* and in each case requires the transformation of known measurements into the terms of these formulae so as to have a guide for the selection of "c" in that class of cases. Until there is a larger collection of special measurements, and also an expression in the special formulae, it is better to be contented with Kutter's.

*Hydraulic tables by Williams and Hazen, Pub. Jno. Wiley & Sons..

APPENDIX.

EXPLANATION OF TABLES.

Tables I. and II. are to give means of correcting the errors to the velocity of approach without the troublesome calculations indicated in the text.

Table I. gives the average velocity through the opening of a weir for different depths. It may be used to determine the velocity of the water as it approaches the weir. This may be found by comparing the cross-section of the channel of approach with the cross-section of the weir. If this is the same then the velocity given in the table would also be the velocity of approach. If the cross-section is, say, three times the area of the weir, then the velocity would be one-third of that given in the table. If the cross-section is seven times as great as the weir, as recommended in the text, then the velocity of approach would be one-seventh of the average velocity in the section of the weir, and thus for depths of two feet, the velocity of approach would be less than three-fourths of a foot, in which case the correction would be small.

Table II. is computed from the Fteley formula and expresses the correction to be given to the results of Tables III. to VI., due to the velocity of approach. This correction is expressed in per cent. The formula is based on experiments limited to 2.5 feet per second.

Tables III. and IV. give the discharges over weirs of unit length. The discharge of weirs of any length may be obtained by multiplying the quantity given for the proper depth in these tables by the length of the weir. This would apply more especially to the Cippoletti weir. If correction for contraction is made, then the length should be decreased by one-fifth of the depth of the water. In both these cases, depths are measured in inches, the formulae being given on page 23.

Table V. gives the discharge over rectangular weirs, from 1 to 10 feet long. In this case the discharge with two complete contractions is given and thus, in order to obtain the same result as in Tables III. or IV., the correction in the last column would be added to the results in the previous columns, or it could be subtracted from the result as obtained by the use of Tables III. and IV.

In both Tables III. and IV. the discharge is computed for every one-sixteenth of an inch. In this case the whole inch is given at the left and the sixteenths are given at the head of the page.

Example: What is the discharge over a weir 45 inches long and with a depth of 11¼ inches with two complete contractions?

Find 11 inches at the left of the page, and the column headed one-fourth inch at the head of the page. Follow this column down until it intersects the line of the 11. At the intersection is the discharge, for a portion of the weir one inch long, which is .2519 cubic feet per second. Then for a weir 45 inches long it is 45 times as much, or 11.3345 second feet, if without contraction. The second column gives the allowance for contraction for 11 inches depth; the eleventh column for a depth of 11½ inches. For 11¼ inches we then take a value intermediate between those for 11 inches and 11½ inches, obtaining the correction .567, the amount by which the discharge is reduced. This, then, leaves the total discharge as 11.335—.567 or 10.77 second feet.

Table VI. is for Cippoletti's trapezoidal weir and thus differs from Table V. in not allowing for contraction, as given in the last column of that table. It is also one per cent. greater.

It will be noticed that the discharges in Table VI. are directly proportional to the length of the weir, while in Table V. they are not. The quantities in Table V. were computed with the coefficient 3⅓ instead of 3.33 of the Francis formula.

Table VII. gives the discharge through right angled notches.

Table VIII. is to enable measurements made in inches to be expressed in decimals of feet.

Depth in all cases in the following tables is measured in still water. See page 25.

TABLE I.

Auxiliary Table for Approximating to Velocity of Approach.

Depth of water over weir		Average velocity in section of weir	Depth of water over weir		Average Velocity in section of weir
in ft.	in in.	in feet per sec.	in ft.	in in.	in ft. per sec.
.25	3	1.665	1.75	21	4.400
.50	6	2.354	2.00	24	4.709
.75	9	2.884	2.25	27	4.995
1.00	12	3.330	2.50	30	5.265
1.25	15	3.723	2.75	33	5.510
1.50	18	4.078	3.00	36	5.765

TABLE II.

Corrections in per cent. for velocity of approach, to be applied to values obtained from Tables III to VI.

Velocity	Head*	DEPTH OVER WEIR, IN FEET											
		.25	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
.25	.0010	00.8	00.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
.50	.0039	03.5	1.8	1.2	0.9	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3
.75	.0087	08.0	4.0	2.6	2.0	1.6	1.3	1.1	1.0	0.9	0.8	0.7	0.7
1.00	.0155	14.3	7.1	4.7	3.5	2.8	2.3	2.0	1.8	1.6	1.4	1.3	1.2
1.25	.0243	22.6	11.1	7.4	5.5	4.4	3.7	3.1	2.7	2.4	2.2	2.0	1.8
1.50	.0350	33.1	16.1	10.7	8.0	6.4	5.3	4.5	4.0	3.5	3.2	2.9	2.6
1.75	.0476	45.7	22.2	14.6	10.9	8.7	7.2	6.2	5.4	4.8	4.3	3.9	3.6
2.00	.0622	60.9	29.2	19.2	14.3	11.4	9.5	8.1	7.1	6.3	5.6	5.1	4.7
2.25	.0787	78.6	37.4	24.5	18.2	14.5	12.0	10.3	9.0	8.0	7.2	6.5	6.0
2.50	.0971	99.1	46.7	30.5	22.6	18.0	14.9	12.7	11.1	9.9	8.9	8.0	7.4
2.75	.1175	121.8	56.9	37.0	27.4	21.8	18.0	15.4	13.4	11.9	10.7	9.7	8.9
3.00	.1398	149.4	69.1	44.8	31.1	26.2	21.7	18.5	16.1	14.3	12.8	11.7	10.7
3.25	.1641	179.6	82.3	53.1	39.1	30.9	25.6	21.8	19.0	16.9	15.1	13.7	12.6
3.50	.1903	213.5	96.9	61.7	45.7	36.1	29.9	25.4	22.2	19.6	17.6	16.0	14.6
3.75	.2185	251.3	113.0	72.3	53.0	41.8	34.5	29.4	25.6	22.6	20.3	18.4	16.8
4.00	.2486	293.1	130.7	82.6	60.9	47.9	39.5	33.6	29.2	25.9	23.2	21.0	19.2

*Head $= \frac{v^2}{64.36}$ v being velocity in feet per second, in first column.

TABLE III.—Discharge Over Weir One Inch Long, in Cubic Feet per Second.

Depth, Inches	Correction to be subtracted for 2 side contractions	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	Correction to be subtracted for 2 side contractions	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
3		.0208	.0347	.0358	.0369	.0380	.0391	.0402	.0414	.0425	.0306	.0437	.0449	.0461	.0437	.0485	.0497	.0509	.0522
4		.0427	.0534	.0547	.0559	.0572	.0585	.0598	.0611	.0624	.0574	.0637	.0651	.0664	.0677	.0691	.0705	.0719	.0732
5		.0746	.0746	.0760	.0775	.0789	.0803	.0817	.0832	.0846	.0947	.0861	.0876	.0891	.0905	.0920	.0936	.0951	.0966
6		.1177	.0981	.0997	.1012	.1027	.1043	.1059	.1075	.1090	.1438	.1106	.1122	.1138	.1154	.1171	.1187	.1203	.1220
7		.1732	.1236	.1253	.1270	.1286	.1303	.1321	.1337	.1354	.2057	.1371	.1388	.1406	.1423	.1440	.1458	.1475	.1493
8		.2417	.1511	.1528	.1546	.1564	.1582	.1600	.1618	.1636	.2812	.1654	.1673	.1691	.1709	.1728	.1746	.1765	.1784
9		.3244	.1802	.1821	.1840	.1859	.1878	.1897	.1916	.193 5	.3714	.1955	.1974	.1993	.2013	.2032	.2052	.2072	.2091
10		.4222	.2111	.2131	.2151	.2171	.2191	.2211	.2231	.2251	.4770	.2271	.2292	.2312	.2332	.2353	.2373	.2394	.2415
11		.5358	.2435	.2456	.2477	.2498	.2519	.2540	.2561	.2582	.5988	.2603	.2625	.2646	.2667	.2689	.2710	.2732	.2753
12		.6660	.2775	.2797	.2818	.2840	.2862	.2884	.2906	.2928	.7376	.2950	.2972	.2995	.3017	.3039	.3062	.3084	.3106
13		.8135	.3129	.3152	.3174	.3197	.3220	.3243	.3265	.3288	.8940	.3311	.3334	.3357	.3380	.3404	.3427	.3450	.3474
14		.9791	.3497	.3520	.3544	.3567	.3591	.3615	.3638	.3662	1.0689	.3686	.3710	.3734	.3758	.3782	.3806	.3830	.3854
15		1.1634	.3878	.3902	.3927	.3951	.3976	.4000	.4025	.4049	1.2628	.4074	.4098	.4123	.4148	.4173	.4198	.4222	.4247
16		1.3672	.4272	.4297	.4323	.4348	.4373	.4398	.4423	.4449	1.4765	.4474	.4500	.4525	.4551	.4576	.4602	.4628	.4653
17		1.5909	.4679	.4705	.4731	.4757	.4783	.4809	.4835	.4861	1.7105	.4887	.4913	.4940	.4966	.4992	.5019	.5045	.5071
18		1.8353	.5098	.5125	.5151	.5178	.5205	.5231	.5258	.5285	1.9654	.5312	.5339	.5366	.5393	.5420	.5447	.5474	.5501
19		2.1009	.5529	.5556	.5583	.5611	.5638	.5666	.5693	.5721	2.2418	.5748	.5776	.5804	.5831	.5859	.5887	.5915	.5943
20		2.3883	.5971	.5999	.6027	.6055	.6083	.6111	.6140	.6168	2.5404	.6196	.6224	.6253	.6281	.6310	.6338	.6367	.6396
21		2.6982	.6424	.6453	.6482	.6510	.6539	.6568	.6597	.6626	2.8614	.6655	.6684	.6713	.6742	.6771	.6801	.6830	.6859
22		3.0309	.6888	.6918	.6947	.6977	.7006	.7036	.7065	.7095	3.2061	.7125	.7154	.7184	.7214	.7244	.7274	.7304	.7333
23		3.3872	.7363	.7393	.7424	.7454	.7484	.7514	.7544	.7575	3.5743	.7605	.7635	.7666	.7696	.7727	.7757	.7788	.7818
24		3.7675	.7849	.7880	.7910	.7941	.7972	.8003	.8034	.8064	3.9668	.8095	.8126	.8157	.8189	.8220	.8251	.8282	.8313
25		4.1722	.8345	.8376	.8407	.8439	.8470	.8501	.8533	.8564	4.3840	.8659	.8628	.8659	.8691	.8723	.8755	.8786	.8818
26		4.6021	.8850	.8882	.8914	.8946	.8978	.9010	.9042	.9074	4.8265	.9107	.9139	.9171	.9203	.9236	.9268	.9301	.9333
27		5.0574	.9366	.9398	.9431	.9463	.9496	.9529	.9561	.9594	5.2948	.9627	.9660	.9693	.9726	.9759	.9792	.9825	.9858
28		5.5388	.9891	.9924	.9957	.9990	1.0023	1.0057	1.0090	1.0123	5.7894	1.0157	1.0190	1.0224	1.0257	1.0291	1.0324	1.0358	1.0391
29		6.0467	1.0425	1.0459	1.0493	1.0527	1.0560	1.0594	1.0628	1.0662	6.3106	1.0696	1.0730	1.0764	1.0798	1.0832	1.0866	1.0901	1.0935
30		6.5814	1.0969	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

For discharges for depths less than 3 inches, use Tables V or VI. The absolute error will be small.

TABLE IV.—Discharge Over Weir One Foot Long, in Cubic Feet per Second.

Depth. Inches	Correction to be subtracted for 2 side contractions	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	Correction to be subtracted for 2 side contractions	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
3	.0208	.4163	.4293	.4425	.4559	.4693	.4829	.4967	.5106	.0262	.5245	.5386	.5529	.5672	.5817	.5963	.6110	.6259
4	.0427	.6409	.6559	.6711	.6864	.7019	.7174	.7331	.7488	.0574	.7647	.7807	.7968	.8130	.8293	.8457	.8622	.8789
5	.0746	.8956	.9125	.9294	.9465	.9636	.9809	.9983	1.0157	.0947	1.0333	1.0510	1.0687	1.0866	1.1045	1.1227	1.1407	1.1590
6	.1177	1.1774	1.1958	1.2143	1.2330	1.2517	1.2705	1.2894	1.3084	.1438	1.3275	1.3467	1.3660	1.3853	1.4048	1.4244	1.4440	1.4637
7	.1732	1.4836	1.5035	1.5235	1.5436	1.5638	1.5840	1.6044	1.6221	.2057	1.6454	1.6660	1.6866	1.7074	1.7283	1.7493	1.7703	1.7914
8	.2417	1.8126	1.8339	1.8553	1.8767	1.8982	1.9199	1.9415	1.9633	.2812	1.9852	2.0071	2.0291	2.0512	2.0734	2.0957	2.1180	2.1404
9	.3244	2.1629	2.1855	2.2081	2.2308	2.2536	2.2765	2.2995	2.3225	.3714	2.3456	2.3688	2.3921	2.4154	2.4388	2.4623	2.4859	2.5095
10	.4222	2.5332	2.5570	2.5809	2.6048	2.6288	2.6529	2.6770	2.7013	.4770	2.7256	2.7499	2.7744	2.7989	2.8235	2.8481	2.8729	2.8977
11	.5358	2.9225	2.9475	2.9725	2.9976	3.0227	3.0480	3.0733	3.0986	.5988	3.1240	3.1495	3.1751	3.2008	3.2265	3.2522	3.2781	3.3040
12	.6660	3.3300	3.3560	3.3822	3.4083	3.4346	3.4609	3.4873	3.5137	.7376	3.5403	3.5668	3.5935	3.6202	3.6470	3.6738	3.7008	3.7277
13	.8135	3.7548	3.7819	3.8091	3.8363	3.8636	3.8910	3.9184	3.9459	.8940	3.9735	4.0011	4.0288	4.0565	4.0844	4.1122	4.1402	4.1682
14	.9791	4.1963	4.2244	4.2526	4.2808	4.3092	4.3375	4.3660	4.3945	1.0689	4.4231	4.4517	4.4804	4.5091	4.5379	4.5668	4.5957	4.6247
15	1.1634	4.6538	4.6829	4.7121	4.7413	4.7706	4.8000	4.8294	4.8589	1.2628	4.8884	4.9180	4.9477	4.9774	5.0072	5.0370	5.0669	5.0968
16	1.3672	5.1268	5.1569	5.1870	5.2172	5.2475	5.2778	5.3081	5.3386	1.4765	5.3690	5.3996	5.4302	5.4608	5.4915	5.5223	5.5531	5.5840
17	1.5909	5.6149	5.6459	5.6770	5.7081	5.7392	5.7705	5.8017	5.8331	1.7105	5.8645	5.8959	5.9274	5.9590	5.9906	6.0222	6.0540	6.0857
18	1.8353	6.1176	6.1495	6.1814	6.2134	6.2455	6.2776	6.3097	6.3420	1.9654	6.3742	6.4066	6.4389	6.4714	6.5039	6.5364	6.5690	6.6017
19	2.1009	6.6344	6.6671	6.7000	6.7329	6.7658	6.7987	6.8318	6.8648	2.2418	6.8980	6.9312	6.9644	6.9977	7.0311	7.0645	7.0979	7.1314
20	2.3883	7.1650	7.1986	7.2323	7.2660	7.2997	7.3336	7.3674	7.4014	2.5404	7.4353	7.4694	7.5035	7.5376	7.5718	7.6060	7.6403	7.6746
21	2.6982	7.7090	7.7435	7.7780	7.8125	7.8471	7.8817	7.9164	7.9512	2.8616	7.9860	8.0208	8.0557	8.0907	8.1257	8.1607	8.1958	8.2310
22	3.0309	8.2662	8.3014	8.3367	8.3721	8.4075	8.4429	8.4784	8.5140	3.2061	8.5496	8.5852	8.6209	8.6567	8.6925	8.7283	8.7642	8.8001
23	3.3872	8.8361	8.8722	8.9083	8.9444	8.9806	9.0168	9.0531	9.0894	3.5143	9.1258	9.1623	9.1987	9.2353	9.2718	9.3085	9.3451	9.3818
24	3.7675	9.4186	9.4554	9.4923	9.5292	9.5662	9.6032	9.6402	9.6773	3.9668	9.7145	9.7517	9.7889	9.8262	9.8635	9.9009	9.9384	9.9758
25	4.1722	10.0134	10.0509	10.0886	10.1262	10.1639	10.2017	10.2395	10.2394	4.3840	10.3153	10.3532	10.3912	10.4292	10.4673	10.5055	10.5436	10.5819
26	4.6021	10.6201	10.6584	10.6968	10.7352	10.7737	10.8122	10.8507	10.8893	4.8265	10.9280	10.9666	11.0054	11.0441	11.0830	11.1218	11.1607	11.1997
27	5.0574	11.2387	11.2777	11.3168	11.3560	11.3951	11.4344	11.4736	11.5131	5.2948	11.5523	11.5917	11.6312	11.6707	11.7102	11.7498	11.7894	11.8291
28	5.5388	11.8688	11.9086	11.9484	11.9882	12.0681	12.0681	12.1080	12.1481	5.7894	12.1881	12.2282	12.2684	12.3086	12.3489	12.3891	12.4295	12.4699
29	6.0467	12.5103	12.5507	12.5912	12.6318	12.6724	12.7130	12.7537	12.7944	6.3106	12.8352	12.8760	12.9169	12.9578	12.9987	13.0397	13.0807	13.1218
30	6.5814	13.1629	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

For discharges for depths less than 3 inches, use Tables V or VI. The absolute error will be small.

TABLE V.

Discharge Over Rectangular Weirs, with and without Contraction.

Formula, $D = 3\frac{1}{3}\ (1 - .2\ H)\ H^{3/2}$

For conditions, see page 29.

Depth, H, of Water on crest Measured in Still Water. See Page 24		DISCHARGE IN CUBIC FEET PER SECOND						
		With Two Complete Contractions.						Correction to be added to each of the preceding to give discharge with no contraction.
In Inches	In Feet	1 Foot Long	1½ Feet Long	2 Feet Long	3 Feet Long	5 Feet Long	10 Feet Long	
0.3	.025	.0133	.0200	.0267	.0400	.0677	.1330	.0000
0.6	.050	.0369	.0556	.0743	.1116	.1863	.3716	.0004
0.9	.075	.0674	.1015	.1350	.2040	.3410	.6830	.0010
1.2	.1	.1033	.1560	.2087	.3132	.5240	1.0519	.0021
1.5	.125	.1438	.2175	.2912	.4385	.7332	1.4695	.0037
1.8	.15	.1879	.2847	.3816	.5753	.9627	1.9312	.0058
2.1	.175	.2355	.3575	.4795	.7235	1.2115	2.4315	.0085
2.4	.2	.2861	.4352	.5843	.8824	1.4787	2.9690	.0119
2.7	.225	.3399	.5177	.6956	1.0513	1.7627	3.5412	.0160
3.0	.25	.3959	.6042	.8126	1.2293	2.0227	4.1462	.0208
3.3	.275	.4543	.6946	.9350	1.4157	2.3771	4.7803	.0264
3.6	.3	.5149	.7888	1.0627	1.6104	2.7059	5.4442	.0328
3.9	.325	.5775	.8863	1.1952	1.8129	3.0482	6.1363	.0401
4.2	.35	.6420	.9871	1.3321	2.0223	3.4032	6.8537	.0483
4.5	.375	.7079	1.0909	1.4732	2.2335	3.7691	7.5976	.0574
4.8	.4	.....	1.1974	1.6189	2.4623	4.1485	8.3645	.0675
5.1	.425	.....	1.3070	1.7680	2.6926	4.5400	9.1565	.0785
5.4	.45	.....	1.4189	1.9221	2.9304	4.9404	9.9775	.0906
5.7	.475	.....	1.5333	2.0790	3.1708	5.3523	10.8094	.1037
6.0	.5	.....	1.6500	2.2392	3.4177	5.7748	11.6672	.1178
6.3	.525	.....	1.7689	2.4029	3.6709	6.2069	12.5469	.1331
6.6	.55	.....	1.8890	2.5698	3.9295	6.6489	13.4474	.1496
6.9	.575	.....	2.0129	2.7395	4.1928	7.0995	14.3668	.1672
7.2	.6	.....	2.1378	2.9123	4.4614	7.5596	15.3052	.1859
7.5	.625	.....	2.2646	3.0881	4.7351	8.0291	16.2641	.2059
7.8	.65	.....	2.3929	3.2665	5.0133	8.5069	17.2409	.2271
8.1	.675	.....	2.5234	3.3478	5.2960	8.9930	18.2354	.2495
8.4	.7	.....	.....	3.6313	5.5836	9.4832	19.2497	.2733
8.7	.725	.....	.....	3.8170	5.8747	9.9906	20.2796	.2984
9.0	.75	.....	.....	4.0052	6.1702	10.5007	21.3262	.3248
9.3	.775	.....	.....	4.1961	6.4704	11.0190	22.3895	.3524
9.6	.8	.....	.....	4.3888	6.7734	11.5444	23.4704	.3816
9.9	.825	.....	.....	4.5833	7.0810	12.0769	24.5659	.4121
10.2	.85	.....	.....	4.7806	7.3929	12.6169	25.6779	.4440
10.5	.875	.....	.....	4.9792	7.7075	13.1641	26.8056	.4775
10.8	.9	.....	.....	.....	8.0257	13.7177	27.9477	.5123
11.1	.925	.....	.....	.....	8.3509	14.2839	29.1164	.5486
11.4	.95	.....	.....	.....	8.6731	14.8461	30.2786	.5864
11.7	.975	.....	.....	.....	9.0012	15.4192	31.4652	.6258
12.0	1.0	.....	.....	.....	9.3333	16.0000	32.6667	.6667
12.3	1.025	.....	.....	.....	9.6685	16.5869	33.8829	.7091
12.6	1.05	.....	.....	.....	10.0058	17.1789	35.1109	.7531
12.9	1.075	.....	.....	.....	10.3471	17.7777	36.3552	.7988
13.2	1.1	.....	.....	.....	10.6907	18.3825	37.6100	.8490
13.5	1.125	.....	.....	.....	11.0376	18.9926	38.8801	.8949
13.8	1.150	.....	.....	.....	11.3866	19.6080	40.1625	.9455
14.1	1.175	.....	.....	.....	11.7388	20.2298	41.4573	.9977
14.4	1.2	.....	.....	.....	12.0935	20.8569	42.7664	1.0516
14.7	1.225	.....	.....	.....	12.4507	21.4893	44.0866	1.1073
15.0	1.25	.....	.....	.....	12.8109	22.1279	45.4204	1.1646
15.3	1.275	.....	.....	.....	13.1733	22.7713	46.7653	1.2237
15.6	1.3	.....	.....	.....	13.5375	23.4189	48.1224	1.2846
15.9	1.325	.....	.....	.....	13.9067	24.0727	49.4927	1.3473
16.2	1.35	.....	.....	.....	14.2740	24.7308	50.8733	1.4117
16.5	1.375	.....	.....	.....	14.6450	25.3946	52.2671	1.4780
16.8	1.4	.....	.....	.....	.....	26.0625	53.6710	1.5460
17.1	1.425	.....	.....	.....	.....	26.7355	55.0870	1.6160
17.4	1.45	.....	.....	.....	.....	27.4127	56.5132	1.6878
17.7	1.475	.....	.....	.....	.....	28.0950	57.9515	1.7615

Discharge Over Rectangular Weirs.—Concluded.

Depth, H, of Water on Crest Measured in still water		DISCHARGE IN CUBIC FEET PER SECOND			
		WITH TWO COMPLETE CONTRACTIONS			Correction to be ADDED to each of the preceding to give discharge with NO contraction.
In Inches	In Feet	3 Feet Long.	5 Feet Long.	10 Feet Long.	
18.0	1.5	.....	28.7814	59.3999	1.8371
18.3	1.525	.....	29.4729	60.8604	1.9146
18.6	1.55	.....	30.1680	62.3300	1.9940
18.9	1.575	.....	30.8681	63.8116	2.0754
19.2	1.6	.....	31.5717	65.3022	2.1588
19.5	1.625	.....	32.2809	66.8049	2.2441
19.8	1.650	.....	32.9935	68.3175	2.3314
20.1	1.675	.....	33.7093	69.8393	2.4207
20.4	1.7	.....	34.4299	71.3719	2.5121
20.7	1.725	.....	35.1546	72.9146	2.6054
21.0	1.750	.....	35.8827	74.4672	2.7009
21.3	1.775	.....	36.6151	76.0286	2.7984
21.6	1.8	.....	37.3510	77.6002	2.8979
21.9	1.825	.....	38.0909	79.1814	2.9996
22.2	1.85	.....	38.8346	80.7726	3.1034
22.5	1.875	.....	39.5812	82.3717	3.2093
22.8	1.9	.....	40.3321	83.9816	3.3173
23.1	1.925	.....	41.0860	85.6005	3.4276
23.4	1.95	.....	41.8436	87.2271	3.5399
23.7	1.975	.....	42.6045	88.8635	3.6545
24.	2.0	.....	43.3695	90.5061	3.771
27.	2.25	.....	.....	107.44	5.06
30.	2.50	.....	.....	125.17	6.59
36.	3.00	.....	.....	162.81	10.39

TABLE VI.

Discharge Over Cippoletti's Trapezoidal Weir of Various Lengths and with Various Depths, and Over Rectangular Weirs Without End Contraction.

Formula, $D = 3.3\frac{2}{3} L H^{\frac{3}{2}}$

Depth of Water on Crest		DISCHARGE IN CUBIC FEET PER SECOND						
In Inches	In Feet	1 Foot Long	1½ Feet Long	2 Feet Long	3 Feet Long	4 Feet Long	5 Feet Long	10 Feet Long
.3	.025	.0135	.0202	.0269	.0404	.0539	.0673	.1347
.6	.05	.0367	.0566	.0754	.1131	.1508	.1885	.3771
.9	.075	.0690	.1035	.1380	.2071	.2761	.3451	.6902
1.2	.10	.1064	.1596	.2128	.3192	.4256	.5319	1.0639
1.5	.125	.1488	.2232	.2976	.4464	.5952	.7440	1.4881
1.8	.15	.1956	.2934	.3912	.5868	.7824	.9780	1.9560
2.1	.175	.2464	.3697	.4929	.7393	.9858	1.2322	2.4644
2.4	.20	.3010	.4515	.6020	.9029	1.2039	1.5049	3.0098
2.7	.225	.3592	.5388	.7184	1.0777	1.4369	1.7961	3.5922
3.0	.25	.4208	.6312	.8417	1.2625	1.6833	2.1041	4.2083
3.3	.275	.4855	.7282	.9709	1.4564	1.9419	2.4273	4.8547
3.6	.30	.5531	.8297	1.1063	1.6594	2.2126	2.7657	5.5314
3.9	.325	.6238	.9358	1.2477	1.8715	2.4954	3.1192	6.2384
4.2	.35	.6972	1.0459	1.3945	2.0917	2.7890	3.4862	6.9724
4.5	.375	.7730	1.1595	1.5460	2.3190	3.0820	3.8649	7.7299
4.8	.40	.....	1.2777	1.7035	2.5553	3.4071	4.2588	8.5177
5.1	.425	.....	1.3993	1.8658	2.7987	3.7316	4.6645	9.3290
5.4	.45	.....	1.5246	2.0328	3.0492	4.0656	5.0820	10.1640
5.7	.475	.....	1.6534	2.2045	3.3067	4.4089	5.5112	11.0225
6.0	.50	.....	1.7854	2.3805	3.5708	4.7610	5.9512	11.9025
6.3	.525	.....	1.9210	2.5614	3.8420	5.1227	6.4034	12.8068
6.6	.55	.....	2.0599	2.7465	4.1198	5.4930	6.8663	13.7326
6.9	.575	.....	2.2018	2.9357	4.4036	5.8715	7.3393	14.6787
7.2	.60	.....	2.3472	3.1293	4.6939	6.2585	7.8231	15.6463
7.5	.625	.....	2.4955	3.3274	4.9911	6.6548	8.3185	16.6370
7.8	.65	.....	2.6462	3.5283	5.2924	7.0565	8.8206	17.6413
8.1	.675	.....	2.8007	3.7343	5.6014	7.4686	9.3357	18.6715

Discharge Over Cippoletti Weirs.—Concluded.

Depth of Water on Crest		DISCHARGE IN CUBIC FEET PER SECOND					
In Inches	In Feet	2 Feet Long	3 Feet Long	4 Feet Long	5 Feet Long	7 Feet Long	10 Feet Long
8.4	.7	3.9437	5.9156	7.8874	9.8593	13.8030	19.7186
8.7	.725	4.1565	6.2347	8.2930	10.3912	14.5457	20.7824
9.0	.75	4.3733	6.5599	8.7466	10.9332	15.3065	21.8675
9.3	.775	4.5942	6.8912	9.1883	11.4854	16.0796	22.9708
9.6	.80	4.8177	7.2265	9.6354	12.0442	16.8619	24.0885
9.9	.825	5.0453	7.5679	10.0906	12.6132	17.6585	25.2264
10.2	.85	.....	7.9154	10.5538	13.1923	18.4692	26.3846
10.5	.875	.....	8.2669	11.0225	13|7781	19.2893	27.5562
10.8	.90	.....	8.6234	11.4978	14.3723	20.1212	28.7446
11.1	.925	.....	8.9850	11.9800	14.9749	20.9649	29.9499
11.4	.95	.....	9.3516	12.4688	15.5860	21.8204	31.1720
11.7	.975	.....	9.7233	12.9644	16.2054	22.6876	32.4019
12.0	1.00	.....	10.1000	13.5667	16.8333	23.5667	33.6667
12.3	1.025	.....	10.4808	13.9744	17.4679	24.4551	34.9359
12.6	1.05	.....	10.8666	14.4888	18.1110	25.3554	36.2220
12.9	1.075	.....	11.2575	15.0100	18.7624	26.2674	37.5249
13.2	1.10	.....	11.6524	15.5365	19.4206	27.1888	38.8412
13.5	1.125	.....	12.0513	16.0684	20.0855	28.1198	40.1711
13.8	1.150	.....	12.4563	16.6071	20.7588	29.0624	41.5177
14.1	1.175	.....	12.8644	17.1525	21.4406	30.0168	42.8812
14.4	1.2	.....	13.2764	17.7019	22.1274	30.9784	44.2548
14.7	1.225	.....	13.6936	18.2581	22.8226	31.9517	45.6453
15.0	1.25	.....	14.1148	18.8197	23.5246	32.9344	47.0492
15.3	1.275	.....	14.5410	19.3880	24.2349	33.9289	48.9699
15.6	1.3	.....	.....	19.9603	24.9503	34.9305	49.9007
15.9	1.325	.....	.....	20.5394	25.6742	35.9439	51.3484
16.2	1.35	.....	.....	21.1238	26.4047	36.9666	52.8095
16.4	1.375	.....	.....	21.7123	26.1404	37.9966	54.2808
16.8	1.4	.....	.....	22.3075	27.8844	39.0382	55.7688
17.1	1.425	.....	.....	22.9082	28.6352	40.0893	57.2704
17.4	1.45	.....	.....	23.5128	29.3910	41.1474	58.7820
17.7	1.475	.....	.....	24.1242	30.1552	42.2173	60.3105
18.0	1.5	.....	.....	24.7396	30.9245	43.2943	61.8490
18.3	1.525	.....	.....	25.3604	31.7005	44.3808	63.4011
18.6	1.55	.....	.....	25.9866	32.4833	45.4766	64.9666
18.9	1.575	.....	.....	26.6182	33.2727	46.5818	66.5455
19.2	1.6	.....	.....	.....	34.0685	47.6959	68.1370
19.5	1.625	.....	.....	.....	34.8702	48.8183	69.7405
19.8	1.65	.....	.....	.....	35.6782	49.9495	71.3565
20.1	1.675	.....	.....	.....	36.4913	51.0878	72.9826
20.4	1.7	.....	.....	.....	37.3111	52.2355	74.6222
20.7	1.725	.....	.....	.....	38.1376	53.3926	76.2752
21.0	1.75	.....	.....	.....	38.9691	54.5568	77.9383
21.3	1.775	.....	.....	.....	39.8074	55.7304	79.6149
21.6	1.8	.....	.....	.....	40.6515	56.9121	81.3030
21.9	1.825	.....	.....	.....	41.5009	58.1013	83.0018
22.2	1.85	.....	.....	.....	42.3577	59.3008	84.7154
22.5	1.875	.....	.....	.....	43.2179	60.5031	86.4358
22.8	1.9	.....	.....	.....	.....	61.7211	88.1730
23.1	1.925	.....	.....	.....	.....	62.9442	89.9203
23.4	1.95	.....	.....	.....	.....	64.1720	91.6743
23.7	1.975	.....	.....	.....	.....	65.4116	93.4452
24.0	2.0	.....	.....	.....	.....	66.6560	95.2228
25.5	2.125	.....	.....	.....	.....	72.999	104.289
27.0	2.25	.....	.....	.....	.....	79.541	113.63
28.8	2.4	.....	.....	.....	.....	87.619	125.18
30.0	2.5	.....	.....	.....	.....	93.156	133.07

SOME PHYSICAL CONSTANTS USEFUL IN CONNECTION WITH THE PRECEDING TABLES.

1 cu. ft. water weighs 62.416 lbs. at32 degrees F.

1 cu. ft. water weighs 62.424 lbs. at 39.3 degrees F.

1 cu. ft. water weighs 62.408 lbs. at 50 degrees F.

1 cu. ft. water weighs 62.300 lbs. at 70 degrees F.

1 cu. ft.=7.48052 U. S. gallons.

1 acre ft.=on acre 1 ft. deep=43,560 cu. ft.=325,851.45 gallons.

1,000,000 U. S. gallons=133,680.6 cu. ft. =3.07 acre ft.

1,000,000 cu. ft.=22.9568 acre feet. =11.574 cu. ft. per sec. for 24 hrs.

1 cu. ft. per sec.=448.8312 gals. per min. =86,400 cu. ft. in 24 hrs. (Nearly 2 acre ft.) =2 acre ft. in 24 hrs., 12 min. =1,000,000 cu. ft. in 11.574 days. =1,000,000 gals. in 1,5472 days.

1 cu. ft. per sec.=38.4 Colorado statute inches. =50 California statute inches.

1.44 cu. ft. per sec. covers 80 acres 6 in. deep in 14 days.

TABLE VII.

Discharge Over Right Angled Triangular Notches, in Cubic Feet per Second.

$Q = .0051\ h^{5/2}$, h measured in inches.

Depth, Inches	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
0	0	.0001	.0001	.0001	.0002	.0003	.0004	.0006	.0009	.0012	.0016	.0020	.0025	.0030	.0036	.0043
1	.0051	.0059	.0068	.0078	.0089	.0101	.0113	.0126	.0140	.0156	.0172	.0189	.0207	.0226	.0246	.0266
2	.0289	.0312	.0336	.0361	.0387	.0415	.0443	.0473	.0504	.0536	.0569	.0604	.0640	.0677	.0715	.0754
3	.0795	.0837	.0880	.0925	.0971	.1018	.1067	.1117	.1169	.1222	.1276	.1332	.1389	.1448	.1507	.1569
4	.1632	.1696	.1762	.1830	.1899	.1970	.2042	.2115	.2191	.2268	.2346	.2426	.2508	.2591	.2676	.2763
5	.2851	.2941	.3033	.3126	.3221	.3318	.3416	.3516	.3618	.3722	.3827	.3934	.4043	.4154	.4267	.4381
6	.4497	.4615	.4735	.4857	.4980	.5107	.5233	.5362	.5493	.5627	.5762	.5898	.6037	.6178	.6320	.6465
7	.6612	.6760	.6911	.7063	.7218	.7375	.7533	.7694	.7856	.8021	.8188	.8357	.8528	.8701	.8876	.9053
8	.9232	.9413	.9597	.9782	.9970	1.0160	1.0352	1.0546	1.0742	1.0941	1.1142	1.1345	1.1550	1.1758	1.1967	1.2179
9	1.2393	1.2609	1.2828	1.3049	1.3272	1.3497	1.3724	1.3954	1.4187	1.4421	1.4658	1.4897	1.5139	1.5382	1.5628	1.5877
10	1.6128	1.6381	1.6636	1.6894	1.7155	1.7417	1.7682	1.7950	1.8220	1.8492	1.8767	1.9044	1.9324	1.9606	1.9890	2.0177
11	2.0467	2.0759	2.1053	2.1350	2.1650	2.1952	2.2256	2.2563	2.2872	2.3185	2.3499	2.3817	2.4136	2.4458	2.4783	2.5110
12	2.5440	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE VIII.

Auxiliary Table to Convert Inches into Decimals of a Foot.

Inches	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
0	.0000	.0052	.0104	.0156	.0208	.0260	.0313	.0365	.0417	.0469	.0521	.0573	.0625	.0677	.0729	.0781
1	.0833	.0885	.0938	.0990	.1042	.1094	.1146	.1198	.1250	.1302	.1354	.1406	.1458	.1510	.1563	.1615
2	.1667	.1719	.1771	.1823	.1875	.1927	.1979	.2031	.2083	.2135	.2188	.2240	.2292	.2344	.2396	.2448
3	.2500	.2552	.2604	.2656	.2708	.2760	.2813	.2865	.2917	.2969	.3021	.3073	.3125	.3177	.3229	.3281
4	.3333	.3385	.3438	.3490	.3542	.3594	.3646	.3698	.3750	.3802	.3854	.3906	.3958	.4010	.4063	.4115
5	.4167	.4219	.4271	.4323	.4375	.4427	.4479	.4531	.4583	.4635	.4688	.4740	.4792	.4844	.4896	.4948
6	.5000	.5052	.5104	.5156	.5208	.5260	.5313	.5365	.5417	.5469	.5521	.5573	.5625	.5677	.5729	.5781
7	.5833	.5885	.5938	.5990	.6042	.6094	.6146	.6198	.6250	.6302	.6354	.6406	.6458	.6510	.6563	.6615
8	.6667	.6719	.6771	.6823	.6875	.6927	.6979	.7031	.7083	.7135	.7188	.7240	.7292	.7344	.7396	.7448
9	.7500	.7552	.7604	.7656	.7708	.7760	.7813	.7865	.7917	.7969	.8021	.8073	.8125	.8177	.8229	.8281
10	.8333	.8385	.8438	.8490	.8542	.8594	.8646	.8698	.8750	.8802	.8854	.8906	.8958	.9010	.9063	.9115
11	.9167	.9219	.9271	.9323	.9375	.9427	.9479	.9531	.9583	.9635	.9688	.9740	.9792	.9844	.9896	.9948
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